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# RECONNAISSANCE OF WATER-QUALITY CHARACTERISTICS OF STREAMS IN THE CITY OF CHARLOTTE AND MECKLENBURG COUNTY, NORTH CAROLINA

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Water Resources Investigations Report 84-4308

Prepared in cooperation with the
CITY OF CHARLOTTE, NORTH CAROLINA, and
MECKLENBURG COUNTY, NORTH CAROLINA

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# RECONNAISSANCE OF WATER-QUALITY CHARACTERISTICS OF STREAMS IN THE CITY OF CHARLOTTE AND MECKLENBURG COUNTY, NORTH CAROLINA

By William H. Eddins and J. Kent Crawford

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Raleigh, North Carolina
1984



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## INTERNATIONAL SYSTEM UNITS

The following factors may be used to convert inch-pound units published herein to the International System of Units (SI).

| Multiply inch-pound unit | By | To obtain SI unit |
|---|---|---|
| **Length** | | |
| inch (in) | 25.4 | millimeter (mm) |
| foot (ft) | 0.3048 | meter (m) |
| mile (mi) | 1.609 | kilometer (km) |
| **Area** | | |
| acre | 4047 | square meter ($m^2$) |
| | 0.4047 | hectare (ha) |
| square mile ($mi^2$) | 0.004047 | square kilometer ($km^2$) |
| | 2.590 | square kilometer ($km^2$) |
| **Volume** | | |
| gallon (gal) | 3.785 | liter (L) |
| | 0.003785 | cubic meter ($m^3$) |
| million gallons (Mgal) | 3785 | cubic meter ($m^3$) |
| cubic foot ($ft^3$) | 0.02832 | cubic meter ($m^3$) |
| acre foot (acre-ft) | 1233.5 | cubic meter ($m^3$) |
| **Flow** | | |
| cubic foot per second ($ft^3/s$) | 28.32 | liter per second (L/s) |
| | 0.02832 | cubic meter per second ($m^3/s$) |
| million gallons per day (Mgal/d) | 0.04381 | cubic meter per second ($m^3/s$) |
| gallon per day (gal/d) | 0.0038 | cubic meter per day ($m^3/d$) |
| **Flow per Area** | | |
| cubic foot per second per square mile $[(ft^3/s)/mi^2]$ | 0.01093 | cubic meter per second per square kilometer $[(m^3/s)/km^2]$ |
| **Temperature** | | |
| degree Fahrenheit ($^oF$) | $5/9(^oF-32)$ | degree Celsius ($^oC$) |
| **Mass** | | |
| ton (short, 2,000 pounds) | 0.9072 | megagram (Mg), or metric ton (t) |
| pounds (lbs) | 453.59 | grams (g) |
| **Specific Conductance** | | |
| micromho ($\mu$mho) per centimeter at 25 $^oC$ | 1 | microsiemens ($\mu$S) |

# RECONNAISSANCE OF WATER-QUALITY CHARACTERISTICS OF STREAMS IN THE CITY OF CHARLOTTE AND MECKLENBURG COUNTY, NORTH CAROLINA

By William H. Eddins and J. Kent Crawford

## ABSTRACT

Water samples were collected from 1979-81 at 119 sites on streams throughout the City of Charlotte and Mecklenburg County, North Carolina, and were analyzed for specific conductance, dissolved chloride, hardness, pH, total alkalinity, total phosphorus, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, silver, zinc, dissolved oxygen, biochemical oxygen demand, fecal coliform bacteria, and fecal streptococcus bacteria. Sampling was conducted during both low flow (base flow) and high flow. Low-flow samples were assumed to represent ground-water quality plus any contributions from point-source effluents. High-flow samples reflect the quality of overland runoff plus contributions from point sources.

Results show that the levels of several water-quality measures including pH, total arsenic, total cadmium, total chromium, total copper, total iron, total lead, total manganese, total mercury, total silver, total zinc, dissolved oxygen, and fecal coliform bacteria at times exceeded North Carolina water-quality standards in various Charlotte and Mecklenburg County streams. Contraventions of standards were infrequent for all of these except iron, manganese, mercury, and fecal coliform bacteria. The iron and manganese standards are primarily for aesthetic purposes and any excesses do not constitute a health hazard. Furthermore, the standards are for total rather than dissolved concentrations of constituents in water, and the suspended fraction of the total concentrations are removed during treatment. The fecal coliform bacteria standards apply only to drinking water sources and to water to be used for swimming. Few of the waters sampled have been assigned swimming or drinking water classifications. There are also suggestions that the mercury concentrations found are natural, background concentrations for the area. A proposal to increase the present mercury standard is under consideration by the North Carolina Environmental Management Commission and therefore, many of the mercury concentrations found during this study may no longer be in violation.

Runoff from nonpoint sources appears to contribute more to the deterioration of streams in Charlotte and Mecklenburg County than point-source effluents. Urban and industrial areas are implicated in contributing various trace elements. Residential and rural areas and municipal waste-water treatment plants contribute high amounts of phosphorus.

# INTRODUCTION

Both point-source discharges and dispersed areas of nonpoint discharges contribute to surface-water quality in the urban environment. Only within the past 15 years, however, has the significance of nonpoint sources in water-quality impairment been realized. This awareness is evident in the Federal Water Pollution Control Act Amendments of 1972 (U.S. Congress, 1973) and in the Clean Water Act of 1977 (U.S. Congress, 1978). Nonpoint pollution comes from sources where the waste is not concentrated into a single outflow. Rather, the pollution source and dishcarge are diffuse, such as degraded water draining from highways and streets, or from residential lawns, agricultural areas, and landfills. Contributions from polluted ground water also constitute a nonpoint source. The diffuse nature of the nonpoint source makes the pollution more difficult to identify, treat, and control than point sources.

Good water quality is important for the growth of an urban area and for the health and enjoyment of its residents. An initial management procedure in the maintenance of high-quality water in an urban environment is a thorough scientific assessment of resource conditions. To this end, the City of Charlotte and Mecklenburg County, North Carolina, in 1979, entered into a cooperative study with the U.S. Geological Survey to determine the quality of water in the streams of the County, to identify degraded parts of streams, and to further characterize certain sources of the degradation.

Ths purpose of this study was to assist in the planning for the future growth of the City by describing present stream-quality conditions and identifying the sources contributing to stream pollution in the Charlotte area. The specific objectives of the study were:

1. To define, in general terms, the present quality of water in Charlotte and Mecklenburg County streams and to relate water quality to land use;
2. To determine the origins of stream pollution in the County; and
3. To propose alternatives for reducing existing pollution and avoiding future pollution.

To accomplish these objectives, two distinct phases of study were planned. The first phase was a water-quality reconnaissance to determine the extent of surface water-quality impairment, and this report addresses that issue. The second study phase will assess in more detail the causes of stream pollution and the quality of groundwater in the area.

The scope of phase one included a compilation of existing water-quality data from the Mecklenburg County Environmental Health Department and from the North Carolina Department of Natural Resources and Community Development. After examining these data for completeness and areal coverage, new sampling stations were established to define the existing water quality of streams throughout the County. More than 100 sampling sites were established with coverage over nearly the entire County and in each major drainage basin.

From 1979 through 1981, water-quality samples were collected during low flow at 119 sites and during high flow at approximately 75 percent of these locations. Sampling during both high and low flow is important for identifying the source of pollutants. That is, during low flow water in the stream is derived primarily from ground-water draining into the channel; thus, any pollutants found in the stream during low flow are transported by ground-water inflow. During high flow, runoff from land surfaces contributes most of the water to a stream and transports nonpoint-source pollutants originating from land-based activities. Point-source pollution contributes to water quality during both high flow and low flow.

This report presents the data from the phase one water-quality reconnaissance. Maps defining the extent of pollution areas constitute the bulk of the report. Explanatory narratives accompany each map.

## Description of the Study Area

The City of Charlotte, Mecklenburg County, is in the south-central part of North Carolina about half way between the Appalachian Mountains and the Atlantic Coastal Plain (fig. 1). The Charlotte-Mecklenburg landscape is typical of the Piedmont physiographic province, characterized by low-lying rounded hills and gentle, rolling ridges. The highest point in the County, about 5 miles north of Mint Hill, is 870 feet above sea level; and the lowest, near Pineville, is 520 feet above sea level.

Streams in the western two-thirds of the County generally flow to the southwest and are part of the Catawba River drainage, whereas streams in the eastern one-third flow eastward and are part of the Rocky River drainage (fig. 2). There are more than 400 miles of streams having drainage areas greater than 1 square mile in Mecklenburg County.

The most common rock types in the County are granite and diorite, which are igneous intrusives. The rocks consist of feldspar, quartz, mica, and accessory minerals, all of which are only slightly soluble and result in dilute ground water entering the stream as base flow. Decomposition of the abundant feldspar accounts for the characteristic clayey soils prevalent in the County and is probably the main determinant of the ground-water chemistry. Colors of the soil vary from shades of pink to red that are imparted by iron-oxide compounds in weathering products of the rocks.

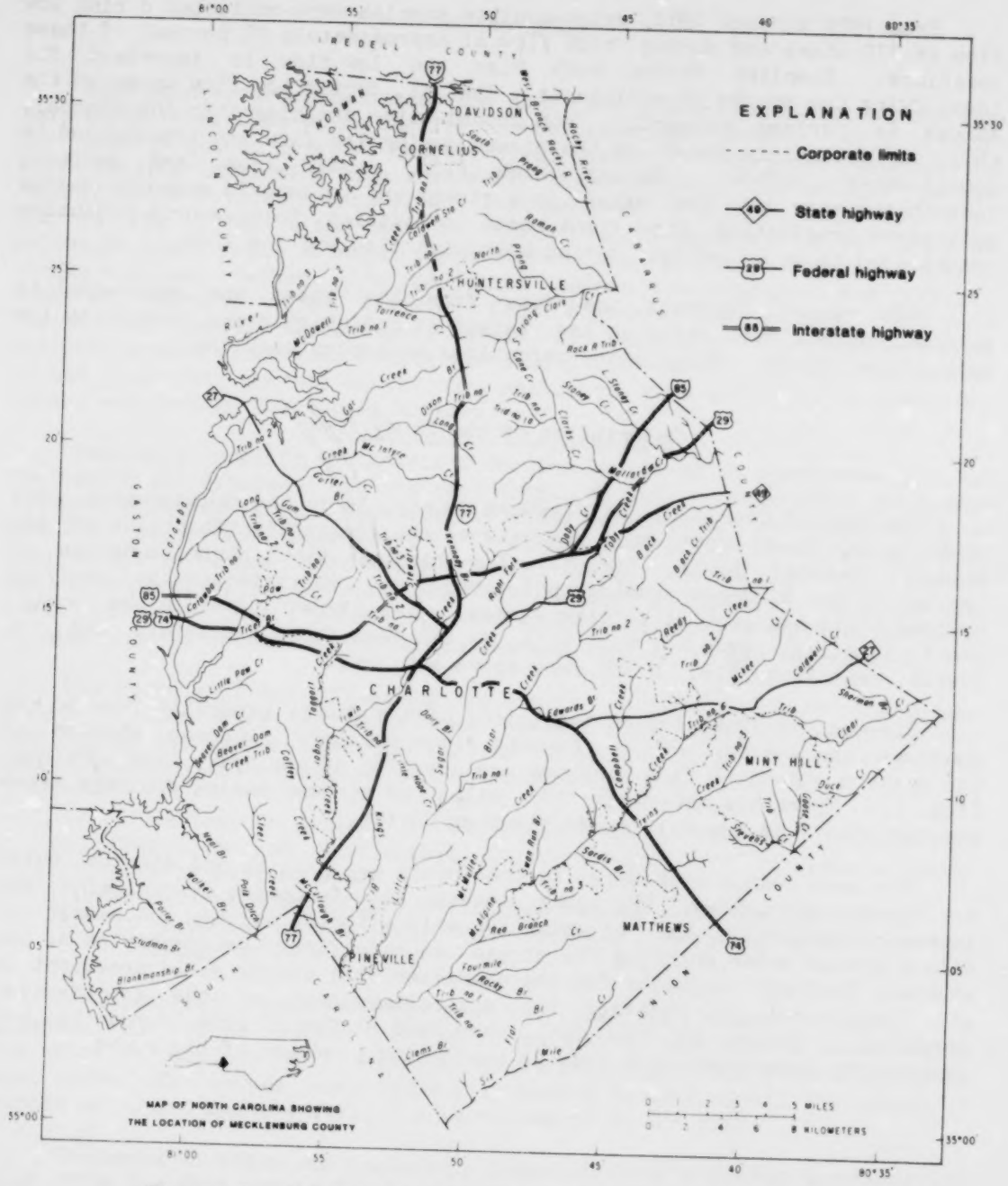



Figure 1.--Municipalities, streams, and major highways in Mecklenburg County, North Carolina

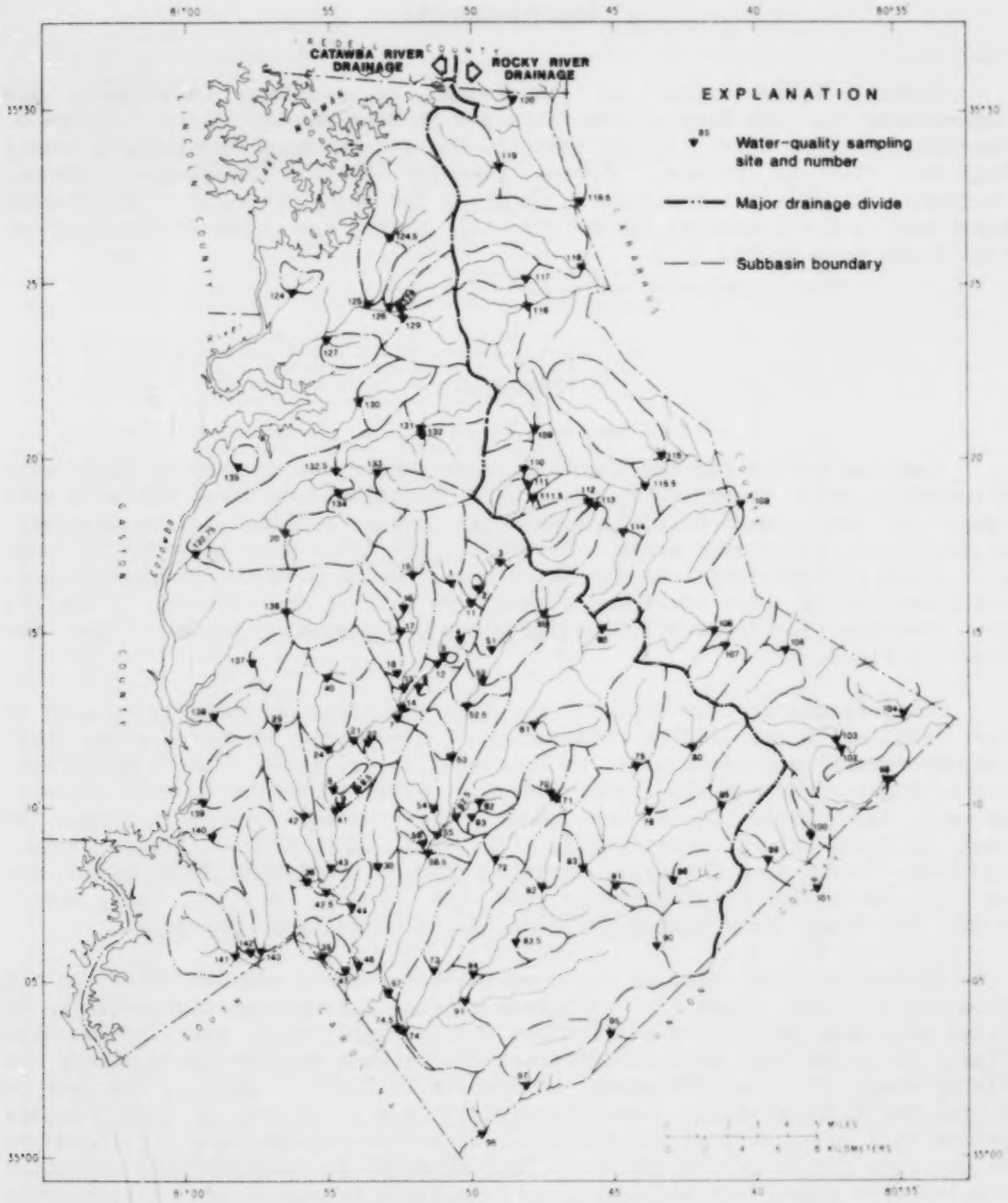



Figure 2.--Location of sampling sites and outline of subbasins and major drainage divide in the City of Charlotte and Mecklenburg County, North Carolina

## Acknowledgments

Special appreciation is expressed to various individuals and departments in the City of Charlotte and in Mecklenburg County. Clarke D. Readling, City of Charlotte Engineer; E. Kenneth Hoffman, Mecklenburg County Engineer; Tom W. Bivens, former Director of the Mecklenburg County Environmental Health Department; and J. Tom Ward, Director of the Health Department's Environmental Laboratory; all played key roles in planning and conducting this study.

## METHODOLOGY

Sampling points for the Charlotte-Mecklenburg water-quality study were selected in order to monitor surface water draining from areas having a wide range of land uses including industrial, urban, suburban, waste disposal, agricultural, and wooded areas. Initially, 125 sites were selected to cover all types of development in the study area. During a field reconnaissance, additional sites were added and others were deleted or relocated to improve the coverage. The final 119 sampling sites are listed in table 1 and are shown in figure 2.

For purposes of this report, the area contributing drainage to each of the sampling sites will be referred to as a subbasin. Larger areas that include several subbasins will be referred to as basins. The Sugar-Irwin, Little Sugar, McMullen, McAlpine, Fourmile, Sixmile, McDowell, Long, Clarke, Mallard, Back, Reedy, Goose, and Clear Creek basins provide drainage for most of Mecklenburg County (fig. 1). The Sugar-Irwin, Little Sugar, McMullen, McAlpine, Fourmile, Sixmile, McDowell, and Long Creek basins are part of the Catawba River drainage and the Clarke, Mallard, Back, Reedy, Goose, and Clear Creek basins are part of the Rocky River drainage.

During low flow, samples were collected at least once at 105 sites and from two to five times at 16 of these sites. During high-flow periods, 69 sites were sampled, but no station was sampled more than once during high flow. No attempt was made to differentiate between samples taken during the rising stage of the hydrograph as opposed to samples taken at the peak or during the falling stage. Low-flow periods were considered as those periods following 7 to 10 days of no rainfall. High-flow periods were considered to be any time the stream height was 1 foot or more above base flow. Low-flow samples were taken from midstream or at multiple points in the stream cross section. Low-flow samples were obtained with an epoxy-painted DH-48 hand-held sampler using depth-integrating techniques discussed by Guy and Norman (1970). High-flow samples were taken at multiple points using a depth-integrating epoxy coated D-74 cable and reel sampler. Samples for determination of organics were taken at multiple points in a stream cross section and were composited using a churn-type splitter (Pickering, 1976). Samples for bacteriological and organic determinations were collected directly in glass containers.

## Table 1.--Water-quality sampling sites

| Site Number | WATSTORE Number | Station Location | Drainage Area ($mi.^2$) | Basin |
|---|---|---|---|---|
| 1 | 0214622200 | Kennedy Branch at Slater Road, nr Charlotte, NC | 2.27 | Sugar-Irwin Creek |
| 2 | 0214620810 | Irwin Creek trib in Statesville Road Landfill Charlotte, NC | .12 | Do. |
| 3 | 0214620750 | Irwin Creek at Dalecrest Road nr Charlote, NC | 3.51 | Do. |
| 4 | 0214624550 | Irwin Creek trib at Burton St. Charlotte, NC | .45 | Do. |
| 5 | 0214622175 | Irwin Creek trib at Irwin Ave. Charlotte, NC | .31 | Do. |
| 6 | 0214624375 | Irwin Creek trib nr Morehead St. Charlotte, NC | .33 | Do. |
| 7 | 0214629170 | Irwin Creek trib in Revolution Park, Charlotte, NC | .41 | Do. |
| 8 | 0214632330 | Sugar Creek trib at rd to Austin Powder Co. Charlotte, NC | .37 | Do. |
| 9 | 0214632340 | Sugar Creek trib 0.1 mi ab mth at York Road Landfill nr Charlotte, NC | 1.02 | Do. |
| 9.5 | 0214632335 | Sugar Creek trib bl toe York Road Landfill nr Charlotte, NC | .87 | Do. |
| 11 | 0214621100 | Irwin Creek at Statesville Road, Charlotte, NC | 5.97 | Do. |
| 12 | 0214623000 | Irwin Creek at I-77 Exit off 5th Street at Charlotte, NC | 11.8 | Do. |
| 13 | 0214628500 | Stewart Creek at west Morehead Street, Charlotte, NC | 11.1 | Do. |
| 14 | 0214628700 | Irwin Creek at West Blvd. Charlotte, NC | 24.6 | Do. |
| 15 | 0214626100 | Stewart Creek at Hoskins Road, Charlotte, NC | 2.65 | Do. |
| 16 | 0214626145 | Stewart Creek trib 3 at access rd to I-85 at Charlotte, NC | 1.31 | Do. |
| 17 | 0214627500 | Stewart Creek trib #2 at Parkway Ave, Charlotte, NC | 1.91 | Do. |
| 18 | 0214628050 | Stewart Creek trib #1 at Berryhill Road, Charlotte, NC | 1.33 | Do. |
| 20 | 0214291400 | Gum Branch at Gum Branch Road nr Thrift, NC | 5.42 | Long Creek |
| 21 | 0214630000 | Irwin Creek nr Charlotte, NC | 30.7 | Sugar-Irwin Creek |
| 22 | 0214629220 | Irwin Creek trib #1, 500 ft above mouth, Charlotte, NC | 1.21 | Do. |
| 24 | 0214631570 | Taggart Creek at Wilmont Road, Charlotte, NC | 6.60 | Do. |
| 25 | 0214633405 | Coffey Creek at NC 160 nr Dixie, NC | 2.46 | Do. |
| 26 | 0214634850 | Coffey Creek trib on Road 0.1 mi ab mouth nr Charlotte, NC | .69 | Do. |
| 30 | 0214636400 | Kings Branch at Arrowood Road nr Charlotte, NC | 2.72 | Do. |
| 35 | 0214638155 | McCullough Branch at Nations Ford Road (SR 1126) nr Pineville, NC | 1.52 | Do. |
| 40 | 0214637850 | Taggart Creek at Wilkinson Blvd nr Charlotte, NC | 2.66 | Do. |
| 41 | 0214632800 | Sugar Creek at Hwy 49, Charlotte, NC | 41.0 | Do. |
| 42 | 0214634750 | Coffey Creek at Shopton Road nr Shopton, NC | 6.82 | Do. |
| 42.5 | 0214635210 | Sugar Creek at I-77 nr Pineville, NC | 55.5 | Do. |
| 43 | 0214633000 | Sugar Creek at Arrowood Road nr Charlotte, NC | 43.7 | Do. |
| 44 | 0214635400 | Sugar Creek at Nations Ford Road nr Charlotte, NC | 58.1 | Do. |
| 46 | 0214638100 | Sugar Creek at Hwy 51 at Pineville, NC | 65.3 | Do. |
| 47 | 0214638180 | McCullough Branch at Hwy 51 nr Pineville, NC | 1.90 | Do. |
| 50 | 0214640150 | Little Sugar Creek at Kentbrook Dr, nr Charlotte, NC | 1.09 | Little Sugar Creek |
| 51 | 0214640475 | Rt Fork Little Sugar Creek at N Tryon St, Charlotte, NC | 2.37 | Do. |
| 52 | 0214640575 | Little Sugar Creek at Belmont Ave, Charlotte, NC | 7.83 | Do. |
| 52.5 | 0214640695 | Little Sugar Creek at Independence Blvd, Charlotte, NC | 10.2 | Do. |
| 53 | 0214641700 | Dairy Branch at Cumberland Ave at Charlotte, NC | 1.04 | Do. |
| 54 | 0214647000 | Little Hope Creek at Seneca Place, Charlotte, NC | 2.63 | Do. |
| 55 | 0214649995 | Little Sugar Creek at Treatment Plant Service Road nr Charlotte, NC | 41.0 | Do. |
| 56 | 0214650520 | Little Sugar Creek trib 7 off Wensley Dr. at Charlotte, NC | .72 | Do. |
| 56.5 | 0214650700 | Little Sugar Creek at Archdale Road Charlotte, NC | 40.8 | Do. |
| 57 | 0214653800 | Little Sugar Creek at Hwy 521 nr Pineville, NC | 49.5 | Do. |
| 60 | 0214642450 | Briar Creek at the Plaza Road nr Charlotte, NC | 1.62 | Do. |
| 61 | 0214643850 | Edwards Branch at Briar Creek Road at Charlotte, NC | 2.51 | Do. |
| 62 | 0214645075 | Briar Creek trib #1 at Colony Road at Charlotte, NC | 1.10 | Do. |
| 62.5 | 0214646100 | Briar Creek at Park Road at Charlotte, NC | 21.4 | Do. |
| 63 | 0214645100 | Briar Creek trib at Barclay Downs Road at Charlotte, NC | .66 | Do. |
| 70 | 0214668200 | McMullen Creek trib at Addison Dr at Charlotte, NC | 1.13 | McAlpine Creek |
| 71 | 0214668100 | McMullen Creek at Robinhood Road at Charlotte, NC | 1.64 | Do. |
| 72 | 0214670000 | McMullen Creek at Sharon View Road nr Charlotte, NC | 6.95 | Do. |
| 73 | 0214673400 | McMullen Creek at Hwy 51 nr Griffith, NC | 14.0 | Do. |
| 74 | 0214675000 | McAlpine Creek below McMullen Creek nr Pineville, NC | 92.0 | Do. |
| 74.5 | 0214676000 | McAlpine Creek at Hwy 521 nr Pineville, NC | 93.6 | Do. |
| 75 | 0214656200 | Campbell Creek at Idlewild Road nr Charlotte, NC | 5.60 | Do. |
| 76 | 0214655275 | McAlpine Creek at Margaret Wallace Road nr Matthews, NC | 8.81 | Do. |
| 80 | 0214655200 | McAlpine Creek at Lawyers Road nr Charlotte, NC | 5.02 | Do. |
| 81 | 0214659810 | Sardis Branch at Sardis Road nr Charlotte, NC | 2.22 | Do. |
| 82 | 0214661225 | Swan Run Branch at Sharon View Road, Charlotte, NC | 2.11 | Do. |

## Table 1.--Water-quality sampling sites--Continued

| Site Number | WATSTORE Number | Station Location | Drainage Area ($mi.^2$) | Basin |
|---|---|---|---|---|
| 83 | 0214660000 | McAlpine Creek at Sardis Road nr Charlotte, NC | 39.6 | McAlpine Creek |
| 83.5 | 0214662240 | Rea Branch at Rea Road nr Charlotte, NC | 1.35 | Do. |
| 84 | 0214665500 | McAlpine Creek at NC 51 nr Pineville, NC | 52.6 | Do. |
| 85 | 0214657900 | Irwins Creek at Lebanon Road nr Charlotte, NC | 5.27 | Do. |
| 86 | 0214658090 | Irwin Creek trib at SR 3474 (Sam Newell Road) nr Charlotte, NC | 2.79 | Do. |
| 90 | 0214667500 | Fourmile Creek at Sr 3448 at Matthews, NC | 3.95 | Do. |
| 91 | 0214667000 | Fourmile Creek at Elm Lane W. nr Pineville, NC | 17.8 | Do. |
| 95 | 0214685380 | Sixmile Creek at Tilly Morris Road nr Providence, NC | 1.78 | Sixmile Creek |
| 96 | 0214685800 | Sixmile Creek at Marvin Road nr Weddington, NC | 20.3 | Do. |
| 97 | 0214685550 | Flat Branch at unnamed Road above mouth nr Weddington, NC | 4.0 | Do. |
| 98 | 0212471760 | Duck Creek at Hwy 218 nr Mecklenburg-Union Co Line | .87 | Goose Creek |
| 99 | 0212467525 | Stevens Creek at SR 3125 nr Mint Hill, NC | 1.63 | Do. |
| 100 | 0212467520 | Goose Creek at SR 1004 nr Mint Hill, NC | 1.94 | Do. |
| 101 | 0212467550 | Goose Creek at SR 1524 nr Mint Hill, NC | 8.50 | Do. |
| 102 | 0212465820 | Clear Creek at SR 3109 nr Allen, NC | 1.57 | Clear Creek |
| 103 | 0212465830 | Clear Creek trib at SR 3109 nr Allen, NC | 5.73 | Do. |
| 104 | 0212465900 | Sherman Branch at Cabarrus Road (SR 3102) nr Allen, NC | 1.27 | Do. |
| 105 | 0212430645 | McKee Creek at SR 2808 nr Harrisburg, NC | 4.08 | Reedy Creek |
| 106 | 0212429235 | Reedy Creek at SR 2826 nr Harrisburg, NC | 10.6 | Do. |
| 107 | 0212429950 | Reedy Creek trib at SR 2822 nr Harrisburg, NC | 2.50 | Do. |
| 108 | 0212426900 | Back Creek at SR 1166 nr Harrisburg, NC | 7.45 | Back Creek |
| 109 | 0212411025 | Clarks Creek trib at SR 2480 nr Croft, NC | 2.85 | Mallard Creek |
| 110 | 0212410512 | Mallard Creek at SR 2480 nr Croft, NC | 2.48 | Do. |
| 111 | 0212410600 | Mallard Creek trib at SR 2494 nr Croft, NC | 1.12 | Do. |
| 111.5 | 0212410650 | Mallard Creek trib at SR 2494 .43 mi. N SR 2464 nr Croft, NC | .35 | Do. |
| 112 | 0212412225 | Doby Creek trib at SR 2665 nr Derita, NC | 2.32 | Do. |
| 113 | 0212412250 | Doby Creek at SR 2665 nr Derita, NC | 3.09 | Do. |
| 114 | 0212414000 | Doby C at NC Hwy 49 nr Newell, NC | 3.60 | Do. |
| 115 | 0212414860 | Stony Creek at US Hwy 29 nr Harrisburg, NC | 6.71 | Do. |
| 115.5 | 0212414600 | Mallard Creek at Mallard Creek Road (SR 2833) nr Harrisburg, NC | 26.10 | Do. |
| 116 | 0212405000 | S Prong Clarke Creek at SR 2442 nr Huntersville, NC | 5.74 | Clarke Creek |
| 117 | 0212406000 | N Prong Clarke Creek at SR 2442 nr Huntersville, NC | 3.63 | Do. |
| 118 | 0212407700 | Ramah Creek at SR 2426 nr Huntersville, NC | 6.19 | Do. |
| 119 | 0212393200 | S Prong W Branch Rocky R at Hwy 73 nr Cornelius, NC | 4.98 | None |
| 119.5 | 0212395300 | Rocky R bl W Branch Rocky R at Cabarrus-Meck Co Line | 39.0 | Do. |
| 120 | 0212391350 | Rocky River at SR 2417 nr Davidson, NC | 9.44 | Do. |
| 124 | 0214264815 | Catawba R trib at SR 2133 nr Hicks Crossroads, NC | 1.22 | Do. |
| 124.5 | 0214265380 | McDowell Creek at Woods Road bl SR 2145 nr Huntersville, NC | 7.68 | McDowell Creek |
| 125 | 0214265400 | McDowell Creek at SR 2136 nr Huntersville, NC | 10.2 | Do. |
| 126 | 0214265810 | Torrence Creek trib #1 at SR 2136 nr Huntersville, NC | 2.59 | Do. |
| 127 | 0214265845 | McDowell Creek trib at SR 2130 nr Huntersville, NC | 1.86 | Do. |
| 128 | 0214265805 | Torrence Creek trib #2 at SR 2136 nr Huntersville, NC | 1.84 | Do. |
| 129 | 0214265800 | Torrence Creek at SR 2138 nr Huntersville, NC | 4.81 | Do. |
| 130 | 0214266080 | Gar Creek at SR 2074 nr Huntersville, NC | 3.68 | none |
| 131 | 0214288000 | Dixon Branch at SR 2113 nr Croft, NC | 4.34 | Long Creek |
| 132 | 0214287800 | Long Creek at SR 2110 nr Croft, NC | 3.14 | Do. |
| 132.5 | 0214290000 | Long Creek nr Paw Creek, NC | 16.4 | Do. |
| 132.75 | 0214291800 | Long Creek at SR 1606 nr Mt. Holly, NC | 33.6 | Do. |
| 133 | 0214288900 | McIntyre Creek at SR 2025 nr Oakdale, NC | 4.94 | Do. |
| 134 | 0214290400 | Gutter Branch at SR 2037 nr Oakdale, NC | 2.48 | Do. |
| 135 | 0214267625 | Catawba River trib at SR 1667 nr Shuffletown, NC | 1.38 | None |
| 136 | 0214295305 | Paw Creek at SR 1641 nr Paw Creek, NC | 5.70 | Do. |
| 137 | 0214295700 | Tiger Branch at Wilkinson Boulevard, Charlotte, NC | 1.32 | Do. |
| 138 | 0214296600 | Little Paw Creek at Mt. Olive Church Road, nr Charlotte, NC | 1.53 | Do |
| 139 | 0214297160 | Beaverdam Creek btw Rock Island Shopton Roads nr Shopton, NC | 4.47 | Do. |
| 140 | 0214297400 | Stowe Branch at Shopton Road nr Shopton, NC | .96 | Do. |
| 141 | 0214678232 | Polk Ditch at Choat Circle nr Pineville, NC | 4.38 | Sugar-Irwin Creek |
| 142 | 0214678232 | Walker Branch at Smith Road nr Pineville, NC | 1.43 | Do. |
| 143 | 0214678200 | Steele Creek at Choat Circle nr Pineville, NC | 7.25 | Do. |

Analyses for dissolved oxygen, pH, temperature, specific conductance and alkalinity were performed at the sampling site. Samples for biological constituents, nutrients, and organic analyses were chilled and preserved and taken to the laboratory for analysis.

Samples for metals analyses were collected in acid-washed bottles and acidified in the field with nitric acid to a pH of 2.0 or less, then taken to the laboratory for analysis. Analyses for all metals were for the total recoverable amount of the metal present. This means that analyses were made without filtering the samples. Consequently, all the suspended sediment in the sample is digested by a strong acid treatment prior to analysis, sometimes leading to very high concentrations of metals. These concentrations are somewhat misleading because much of the metal found in the sample was undoubtedly bound in the suspended sediments and was not biologically avaliable.

All laboratory analyses were made by the Mecklenburg County Environmental Health Laboratory using methods described in Skougstad and others (1979). This laboratory participates in the quality-assurance program of the U.S. Geological Survey's National Water Quality Laboratories, Atlanta, Ga. and Denver, Colo. Results of quality-assurance analyses are on file in the Charlotte office of the U.S. Geological Survey. For some of the trace elements, different techniques were used to analyze for the same constituent at different times during the study. This results in more than one detection limit for these constituents.

The design of the study creates the existance of some uncontrolled variables which require that the results be interpreted with caution. For example, more than one high-flow sample per station is desirable for characterizing high-flow water quality. This is especially important because high-flow samples were not consistently taken during the rise, at the peak, or during the fall. Water quality varies significantly during these different parts of the hydrograph. Also, concentrations of metals in dissolved as well as total forms would be beneficial. Lower detection limits are needed for certain chemicals to fully evaluate the concentrations present. So, within limits, the data presented in this report are instructive and serve their intended purpose of a reconnaissance level characterization of the surface-water quality of the City of Charlotte and Mecklenburg County.

Concentrations of constituents found in Charlotte and Mecklenburg County waters are compared to existing standards and criteria for those constituents having State water-quality standards or U.S. Environmental Protection Agency criteria. Standards are enforceable State laws, whereas criteria are limits recommended for the protection of certain water uses. Standards are also related to water use. Streams are classified according to their projected use with different standards for each classification. In North Carolina, streams classified as Class A are protected for use as public water supplies; Class B streams are protected for use as primary recreation resources such as swimming and water skiing; Class C streams are for secondary recreation, fishing, and agriculture (North Carolina Environmental Management Commission, 1979).

## WATER-QUALITY CHARACTERISTICS

Surface water in Charlotte and Mecklenburg County, as elsewhere, is a composite of (1) water moving through the ground-water system to streams; (2) water flowing over the land surface; (3) precipitation falling directly onto stream surfaces; and (4) effluent water discharged directly to streams from industries and municipal wastewater treatment plants. During periods of little precipitation, streamflow is low, and most of the water flowing in a stream originates from the ground-water system. Thus, in the absence of point source pollution, the quality of water in a stream during low-flow, or base-flow, conditions depends on the quality of ground water reaching the stream and is reflective, for the most part, of ground-water quality. During periods of heavy rainfall, the infiltration capacity of the soil is exceeded and water runs overland rather than infiltrating into the ground. This water enters streams and dominates the quality of surface water during high flow.

In the absence of point-sources, pollution found during low flow indicates possible ground-water contamination. Sources of ground-water contamination include underground waste-disposal sites, leaking sewer lines, septic tanks, and any pollutant that has infiltrated into the ground from the surface. Landfills are one potential source of ground water pollution and locations of both active and inactive landfills in Mecklenburg County are shown in figure 3 and listed in table 2.

Contamination in high-flow samples suggests overland runoff as the contaminant source. Potential contributors to overland runoff include inputs from agricultural operations, street runoff, and accumulated pollutants that have settled from the atmosphere.

Industrial and municipal effluents are discharged directly into streams during both low and high flow. Figure 3 shows the locations of 80 waste-effluent dischargers in Mecklenburg County that have received permits from the North Carolina's Department of Natural Resources and Community Development as of July 1, 1982 (Jay Sauber, personal communication, January, 1983). Names of the dischargers are listed in table 3.

In this section of the report, concentrations of several water-quality constituents in the streams of Charlotte and Mecklenburg County are determined for both low-flow and high-flow conditions.

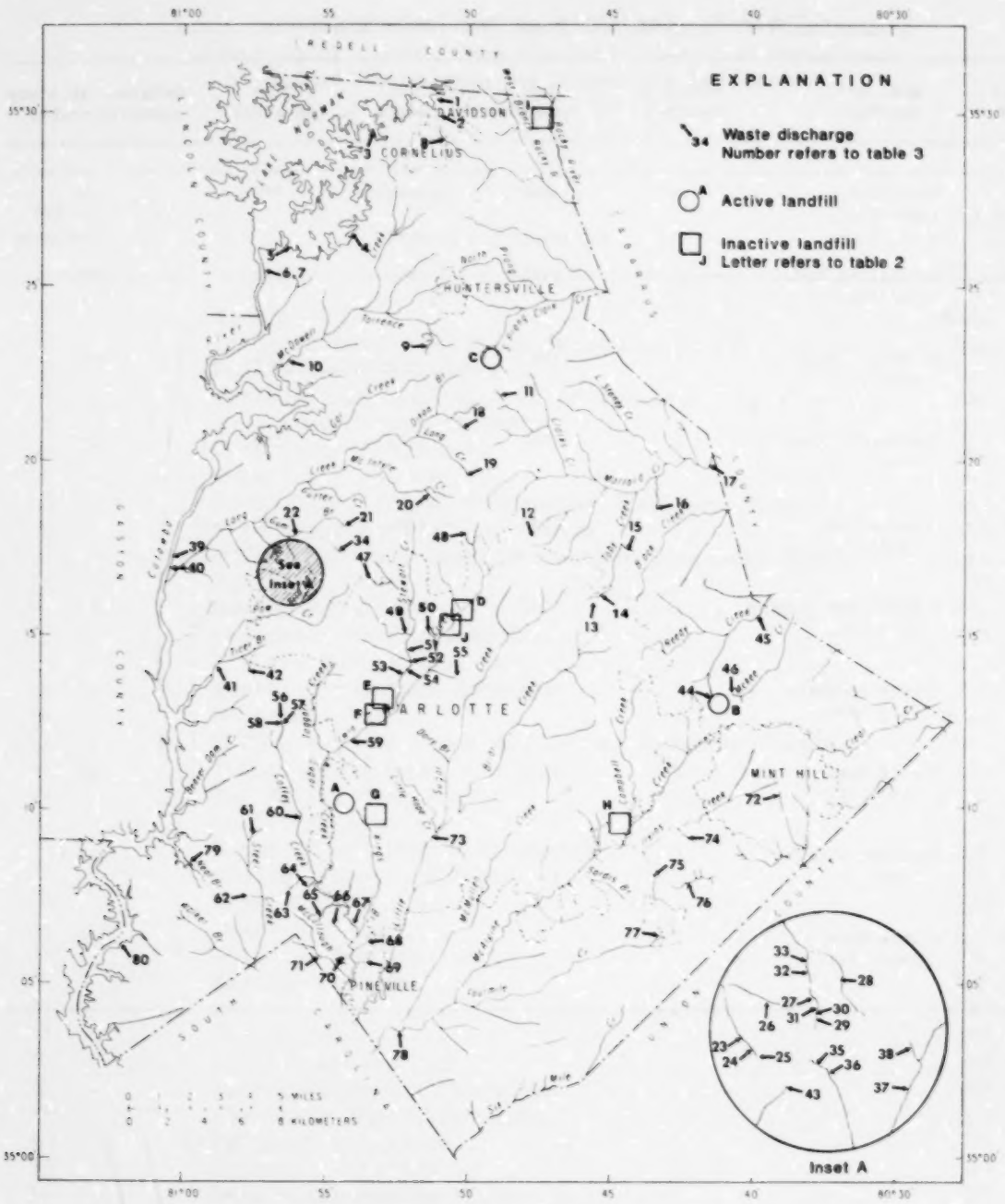



Figure 3.--Location of waste-effluent discharges and landfills in Mecklenburg County, North Carolina

Table 2.--Landfills in Mecklenburg County

| Map number | Name of landfill | Active or inactive | Date opened | Date closed | Size (in acres) | Contained in study subbasin number |
|---|---|---|---|---|---|---|
| A | York Road landfill. | A | 1968 | Operating | 375 | 9 |
| B | Harrisburg Park landfill. | A | 1973 | do. | 120 | 107 |
| C | Holbrooks Road landfill. | A | 1968 | do. | 65 | 116 |
| D | Statesville Road landfill. | I | 1940 | 1970 | 140 | 11 |
| E | Remount Road landfill. | I | 1930 | 1951 | 20 (est) | 21 |
| F | Tremont and Wilmore fill pit. | I | 1942 | 1955 | 10 (est) | 21 |
| G | Tyvola-Archdale fill area. | I | 1960 | 1964 | 23 | 30 |
| H | Monroe Road landfill. | I | 1968 | 1972 | 36 | 83 |
| I | Davidson City landfill. | I | 1964 | 1974 | ? | 119.5 |
| J | Double Oaks landfill. | I | ? | 1930's | ? | 12 |

Table 3.--Waste-water effluent discharges in Mecklenburg County under permit from the North Carolina Department of Natural Resources and Community Development, July 1, 1982

| Map number | Name of discharger | Contained in study subbasin number |
|---|---|---|
| 1 | General Tire | None |
| 2 | Davidson Municipal Water Treatment Plant | Do. |
| 3 | Roland Brown Residence | Do. |
| 4 | Huntersville Municipal Water Treatment Plant | Do. |
| 5 | Duke Power Training Center | Do. |
| 6 | Duke Power McGuire #1 | Do. |
| 7 | Duke Power McGuire #2 | Do. |
| 8 | Davidson Municipal Wastewater Treatment Plant | 119 |
| 9 | N.C. Department of Corrections | 129 |
| 10 | CMUD - McDowell Creek Wastewater Treatment Plant | None |
| 11 | Berstorff Corp. | 109 |
| 12 | Derita School | 112 |
| 13 | Evergreen Mobile Home Park | 114 |
| 14 | Killian Mobile Home Park | 114 |
| 15 | Newell Elementary School | 114 |
| 16 | Mineshaft Too | None |
| 17 | CMUD - Mallard Creek Wastewater Treatment Plant | Do. |
| 18 | Yellow Freight Co. | 131 |
| 19 | Key Mobile Home Park | 132 |
| 20 | Go Enterprises | 133 |
| 21 | Sunset Grove Mobile Home Park | 20 |
| 22 | Coulwood Shopping Center | 20 |
| 23 | Crown Central Corp. | 132.75 |
| 24 | Shell Oil Co. | 132.75 |
| 25 | National Terminal Corp. | 132.75 |
| 26 | American Oil Co. | 132.75 |
| 27 | do. | 132.75 |
| 28 | Texaco Inc. | 20 |
| 29 | Cities Service Oil | 20 |
| 30 | Intercontinental Petroleum | 20 |
| 31 | Charlotte Facilities Inc. | 20 |
| 32 | Phillips Petroleum | 20 |
| 33 | Colonial Pipeline | 20 |
| 34 | Leaksville Woolen Mills | 20 |
| 35 | Hess Oil Co. | 136 |
| 36 | Union Oil Co. | 136 |
| 37 | Fleet Transport | 136 |
| 38 | American Petrofina | 136 |
| 39 | A & E Thread Mills | None |

Table 3.--Waste-water effluent discharges in Mecklenburg County under permit from the North Carolina Department of Natural Resources and Community Development, July 1, 1982--Continued

| Map number | Name of discharger | Contained in study subbasin number |
|---|---|---|
| 40 | Martin-Marietta--Sodeyco | None |
| 41 | American Cyanamid | Do. |
| 42 | Berryhill Elementary School | Do. |
| 43 | Exxon Corp. | 136 |
| 44 | J. H. Gunn Junior High School | 107 |
| 45 | County Est. Utility Co. | None |
| 46 | Lamplighter East Mobile Home Park | 105 |
| 47 | Hoskins Water Treatment Plant | 16 |
| 48 | Ranson Junior High School | 11 |
| 49 | Union Carbide | 13 |
| 50 | CMUD--Vest Water Treatment Plant | 12 |
| 51 | Forshaw Chemical | 13 |
| 52 | Carolina Concrete | 13 |
| 53 | Armour & Co. | 13 |
| 54 | Clorox Co. | 13 |
| 55 | Discovery Place Museum | 14 |
| 56 | Piedmont Aviation | 25 |
| 57 | Eastern Airlines | 25 |
| 58 | Delta Airlines | 25 |
| 59 | CMUD—Irwin Creek Wastewater Treatment Plant | 41 |
| 60 | Hunter-Jersey Farms | 42 |
| 61 | Olympic High School | 143 |
| 62 | Union Chemicals | 143 |
| 63 | Duff-Norton-Steele | 42.5 |
| 64 | General Tire | 42.5 |
| 65 | Armstrong Cork | 44 |
| 66 | Mildrex Corp. | 44 |
| 67 | Vulcan Materials | 46 |
| 68 | Elson Thermoplastics | 46 |
| 69 | Tillett Chemical Co. | 46 |
| 70 | Yeargin Construction | 46 |
| 71 | Martin-Marietta--Arrowood | 35 |
| 72 | Bain Elementary School | 101 |
| 73 | CMUD--Sugar Creek Wastewater Treatment Plant | 56.5 |
| 74 | Bruce Rowell Residence | 83 |
| 75 | Martin-Marietta--Charlotte | 83 |
| 76 | Wood Hollow Subdivision | 86 |
| 77 | Matthews Wastewater Treatment Plant | 90 |
| 78 | CMUD--McAlpine Creek Wastewater Treatment | 74.5 |
| 79 | Westinghouse Electric | None |
| 80 | McDowell Park Wastewater Treatment Plant | Do. |

## Specific Conductance

Specific conductance is a measure of the ability of water to conduct an electrical current. As such, it reflects the total amount of all dissolved ions in water and can be used as an indicator of the total dissolved inorganic solids concentration of the water. No water-quality criteria or standards have been set for specific conductance. Hem (1970) indicates that dissolved-solids concentrations, measured in milligrams per liter (mg/L), are usually between 55 and 75 percent of specific conductance values, in micromhos per centimeter ($\mu$mho/cm) at 25 degrees Celsius. Thus, using 0.65 as a conversion factor between specific conductance and dissolved solids, specific conductance values greater than about 385 mho/cm indicate dissolved solids concentrations of more than 250 mg/L and, depending on the chemical makeup of the water, might be objectionable for a water supply source (U. S. Environmental Protection Agency, 1976a).

During low flow, water samples from 37 sampling sites in Charlotte and Mecklenburg County had specific conductance values of 150 $\mu$mho/cm or less. These low values are found primarily around the perimeter of the County, particularly in streams at the eastern and northern edges (fig. 4). Higher specific conductance values, generally between 150 and 300 $\mu$mho/cm, were found for streams within the city limits of Charlotte and in the southern sections of the County. In three small tributaries to Irwin Creek and Irwin Creek itself near the center of the City of Charlotte, values exceeded 600 $\mu$mho/cm. At sampling sites immediately downstream from wastewater treatment plants on Irwin Creek, Little Sugar Creek, and McAlpine Creek, specific conductance concentrations were greater than 400 $\mu$mho/cm. In general, streams in residential areas served by city sewers tended to have conductance values around 150 $\mu$mho/cm or roughly 50 percent higher than natural. Streams in residential areas using septic tanks had mean specific conductance values ranging from about 150 to 250 $\mu$mho/cm, whereas in the central city, mean values ranged from 300 to 400 $\mu$mho/cm. Streams originating from older landfills had mean values of 600 to 800 $\mu$mho/cm but conductance values in streams that drain from modern landfills did not exceed 300 $\mu$mho/cm.

During high flow (fig. 5), the highest measured value for specific conductance was 325 $\mu$mho/cm, found on McCullough Branch (site 35) in the southern part of the County (table 4). Specific conductance values were invariably lower during high flow than low flow. Table 5 compares specific conductance values during high and low flows for four of the major streams draining the Charlotte area.

Table 4.--Summary information for specific conductance from this study

| Water-Quality Standards and Criteria | | | |
|---|---|---|---|
| Value limits (μmho/cm) | Applicable to | Authority | Comments |
| None | | | |

| Highest Values From This Study | | | | | |
|---|---|---|---|---|---|
| | Low flow | | | High flow | |
| Rank | Mean value (μmho/cm) | Sampling site | Rank | Value (μmho/cm) | Sampling site |
| 1 | 880 | 2 | 1 | 325 | 35 |
| 2 | 736 | 6 | 2 | 216 | 46 |
| 3 | 630 | 7 | 3 | 135 | 21 |
| 4 | 625 | 11 | 3 | 135 | 74.5 |
| 5 | 560 | 74.5 | 5 | 130 | 56.5 |
| 6 | 480 | 41 | 5 | 130 | 129 |
| 7 | 460 | 56.5 | 7 | 129 | 132 |
| 8 | 440 | 57 | 8 | 128 | 6 |
| 9 | 413 | 21 | 9 | 115 | 91 |
| 10 | 370 | 90 | 10 | 114 | 17 |

Table 5.--Specific conductance values at the downstream end of larger streams in Mecklenburg County, North Carolina

| Site number | Stream name | Specific conductance (μmho/cm) | |
|---|---|---|---|
| | | Low flow[1/] | High flow |
| 46 | Sugar Creek | 336 | 216 |
| 57 | Little Sugar Creek | 440 | 110 |
| 73 | McMullen Creek | 265 | 74.5 |
| 74.5 | McAlpine Creek | 560 | 135 |

[1/]Average of two samples.

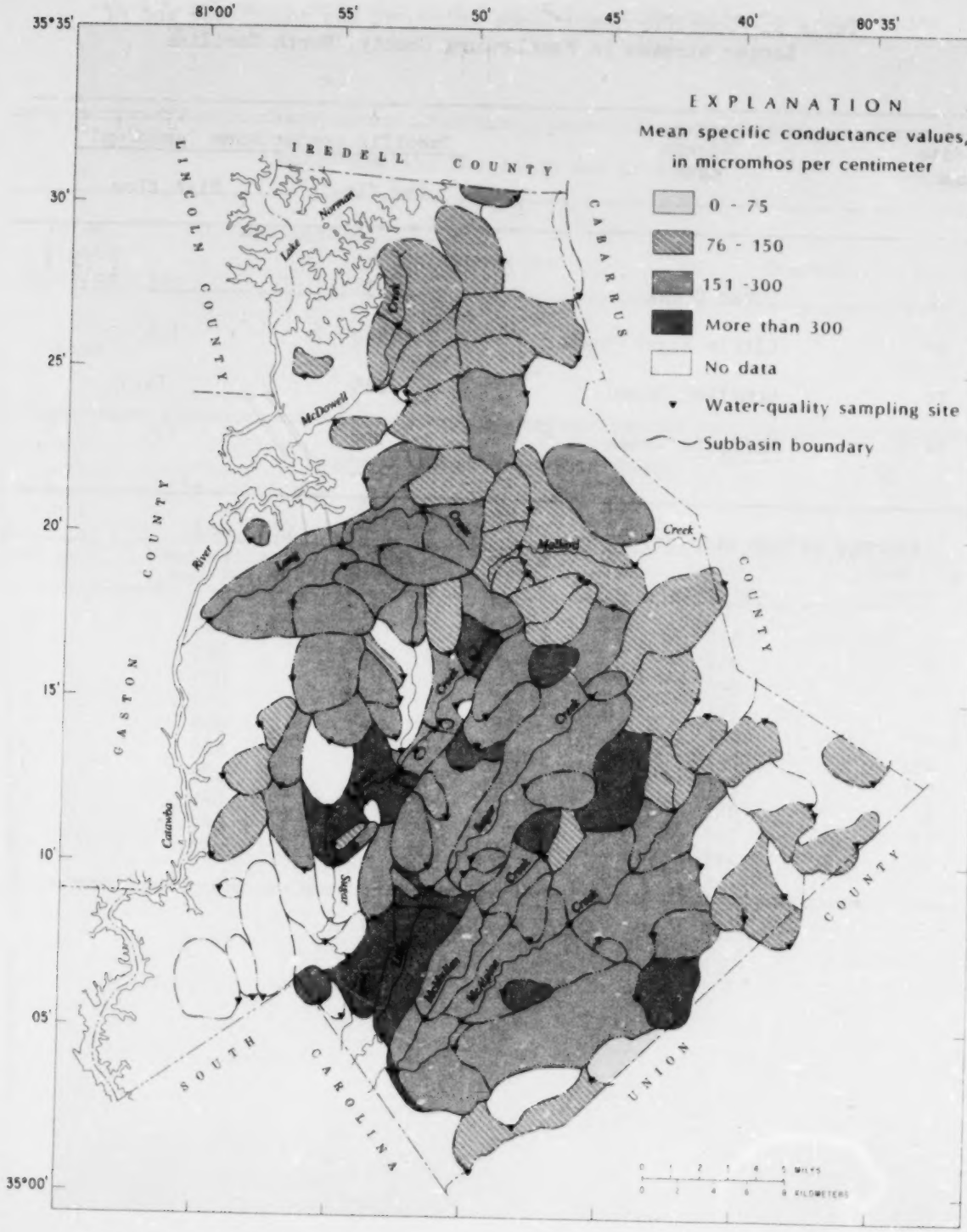



Figure 4.--Mean specific conductance values during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

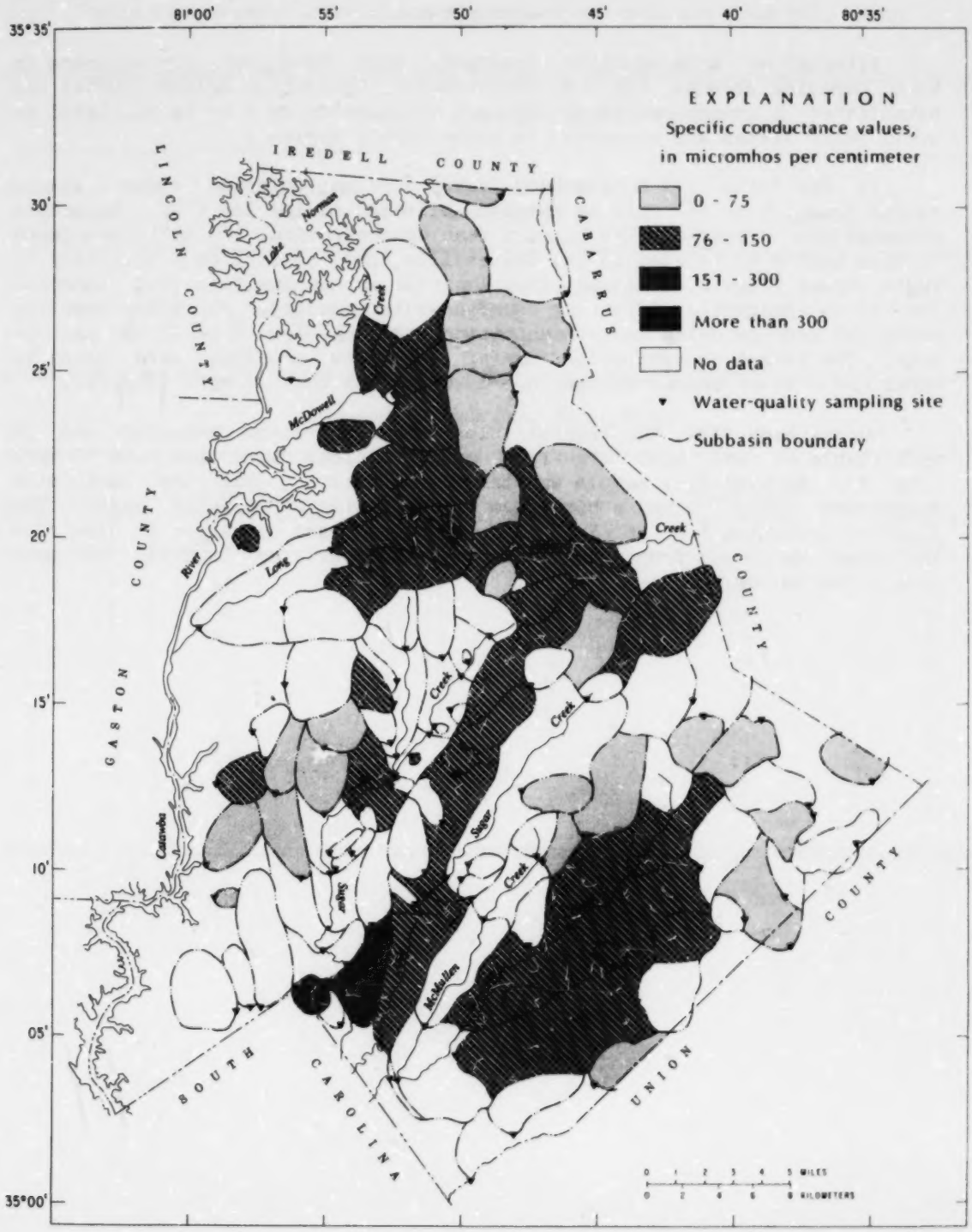



Figure 5.--Specific conductance values during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Chloride

Although no water-quality standards have been set for chloride in North Carolina streams, the U.S. Environmental Protection Agency (1976a) has established a concentration of 250 mg/L of chloride as a criterion level to avoid salty tastes and corrosion in water-supply systems.

In Charlotte and Mecklenburg County streams, chloride concentrations ranged from 1.9 to 150 mg/L in samples collected during low flow. No sample exceeded EPA criteria. The highest mean concentration, 140 mg/L, was found at site number 2, located in the Statesville Road landfill on a tributary to Irwin Creek (fig. 6, table 6). This landfill is now inactive but leachate from it is apparently affecting surface-water quality. All other sampling sites had average chloride concentrations during low flow of 100 mg/L or less. The lowest concentrations during low flow sampling were found in rural areas where concentrations are usually less than 10 mg/L (fig. 6).

During high flow, the highest chloride concentration measured was 38 mg/L (table 6) and most high-flow concentrations were less than 10 mg/L (fig. 7). No high-flow sample was taken at site 2, but the next site downstream, site 11, had a high-flow concentration of only 8.4 mg/L. The elevated concentration at low flow and a reversed situation at high flow indicates an input from ground water and the abandoned landfill is most likely the source.

Table 6.--Summary information for dissolved chloride from this study

| Water-Quality Standards and Criteria | | | |
|---|---|---|---|
| Concentration limits (mg/L) | Applicable to | Authority | Comments |
| 250 | Domestic water supplies. | U.S. Environmental Protection Agency (1976a). | |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L) | Sampling site | Rank | Concentration (mg/L) | Sampling site |
| 1 | 140 | 2 | 1 | 38 | 35 |
| 2 | 95 | 11 | 2 | 26 | 104 |
| 3 | 60 | 70 | 3 | 24 | 41 |
| 4 | 57 | 52.5 | 4 | 20 | 46 |
| 5 | 51 | 74.5 | 5 | 18 | 17 |
| 6 | 47 | 41 | 6 | 15 | 21 |
| 7 | 46 | 90 | 7 | 14 | 95 |
| 8 | 43 | 6 | 8 | 13 | 14 |
| 9 | 37 | 46 | 9 | 12 | 129 |
| 10 | 36 | 60 | 10 | 11 | 139 |

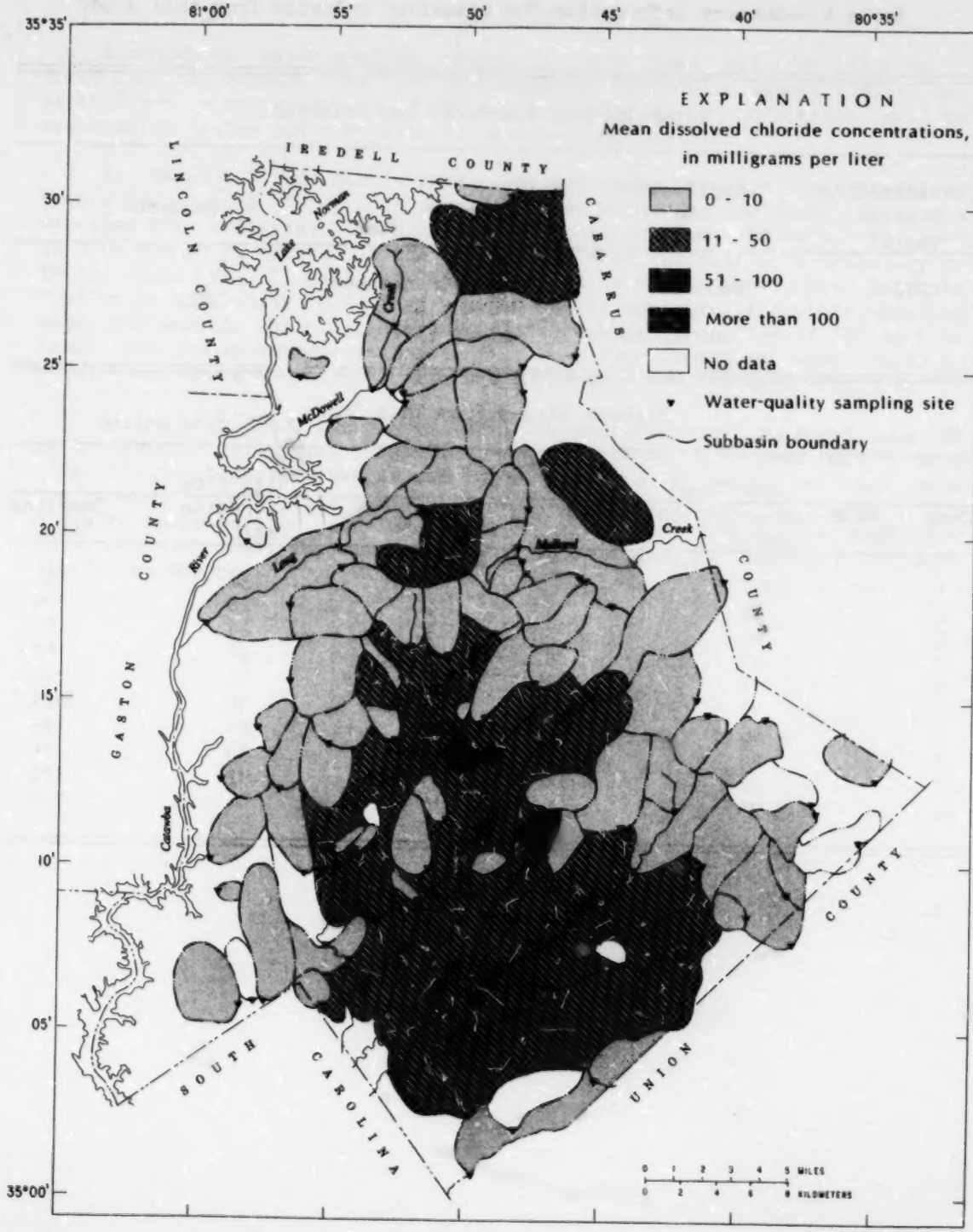



Figure 6.--Mean dissolved chloride concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

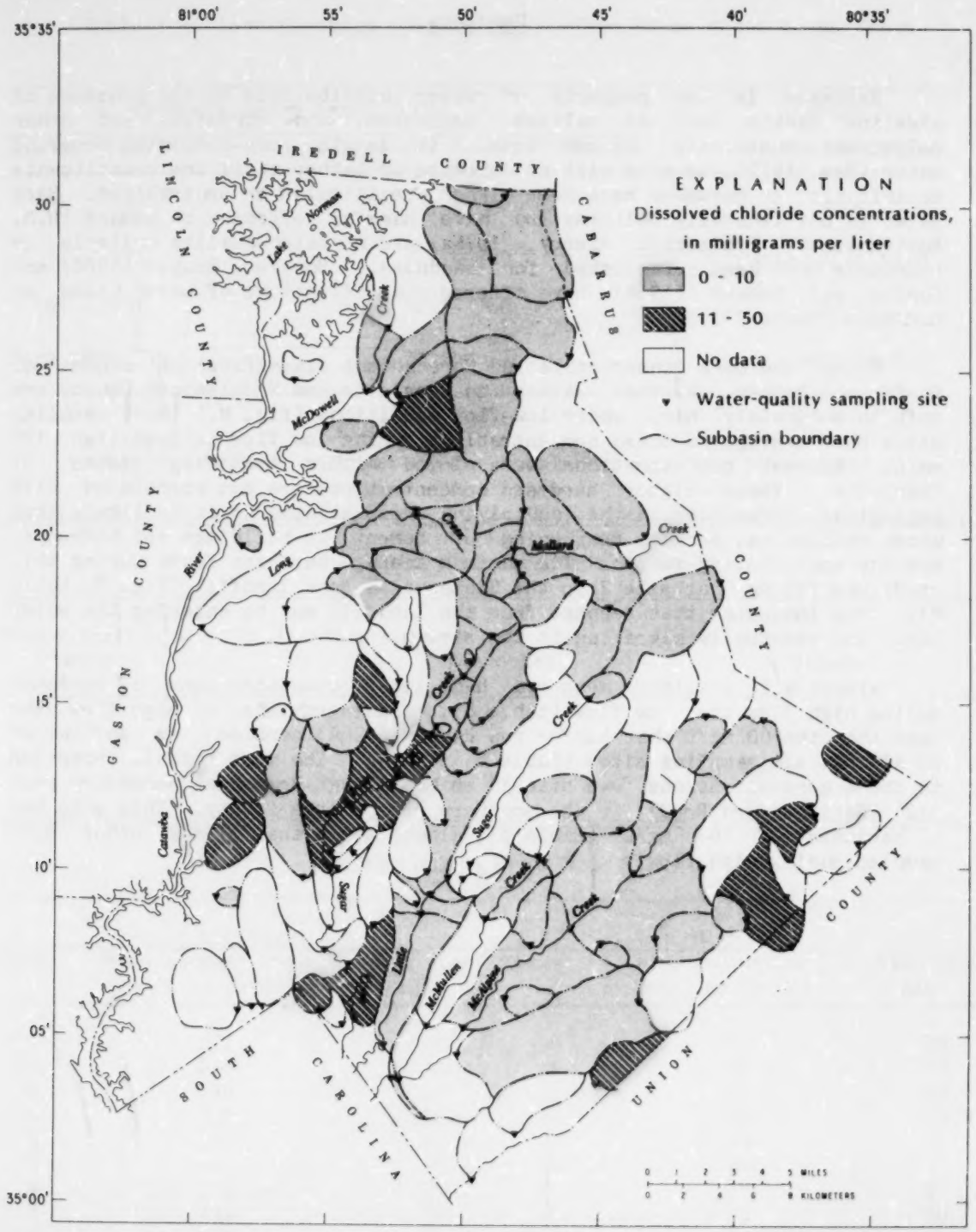



Figure 7.--Dissolved chloride concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Hardness

Hardness is the property of water attributable to the presence of alkaline earths such as calcium, magnesium, and strontium and other polyvalent, positively charged ions. It is the soap-consuming power of water (Hem, 1970), as soap will not cleanse or lather until the constituents contributing to hardness have been either precipitated or neutralized. Hard water is not generally believed to have harmful effects on humans (U.S. Environmental Protection Agency, 1976a) and no water-quality criteria or standards have been established for hardness. However, Sawyer (1960) and Durfor and Becker (1964) have offered classifications of water based on hardness (table 7).

Using the more conservative and more recent classification scheme of Durfor and Becker, surface waters in Charlotte and Mecklenburg County are soft to moderately hard under low-flow conditions (fig. 8.) Most sampling sites have average hardness concentrations during low flow of less than 120 mg/L. Highest concentrations were found within the city limits of Charlotte. These higher hardness concentrations are not correlated with geological differences in the underlying rock strata, so it is likely that urban influences, perhaps weathering of cement in buildings and highways, are the contributing factor. The maximum average hardness found during this study was 320 mg/L at site 2 in the Statesville Road landfill (fig. 8, table 8). This indicates that seepage from the landfill may be entering the water table and eventually migrating to the stream.

Almost all stations measured had lower concentrations of hardness during high flow than low flow (table 8). Concentrations at high flow were less than the 60 mg/L that Durfor and Becker (1964) consider as soft water at all but six sampling sites (table 8, fig. 9). The most notable exception to these generalizations was site 35 on McCullough Branch at secondary road 1126 (Nations Ford Road) in the southern part of the County. This site had a hardness of 160 mg/L (table 8), almost twice that of any other site sampled during high flow.

Table 7.--Classification schemes for surface water based on hardness

| Hardness range (mg/L $CaCO_3$) | | Water characterization |
|---|---|---|
| Sawyer (1960) | Durfor and Becker (1964) | |
| 0 - 75 | 0 - 60 | Soft. |
| 75 - 150 | 61 - 120 | Moderately hard. |
| 150 - 300 | 121 - 180 | Hard. |
| More than 300 | More than 180 | Very hard. |

Table 8.--Summary information for total hardness from this study

| Water-Quality Standards and Criteria | | | |
|---|---|---|---|
| Concentration limits | Applicable to | Authority | Comments |
| None | | | |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L as $CaCO_3$) | Sampling site | Rank | Concentration (mg/L as $CaCO_3$) | Sampling site |
| 1 | 320 | 2 | 1 | 160 | 35 |
| 2 | 240 | 11 | 2 | 85 | 84 |
| 3 | 150 | 35 | 3 | 65 | 83.5 |
| 4 | 130 | 83.5 | 4 | 64 | 74.5 |
| 5 | 120 | 62.5 | 4 | 64 | 91 |
| 5 | 120 | 5 | 6 | 60 | 14 |
| 7 | 110 | 124 | 7 | 57 | 81 |
| 7 | 110 | 17 | 7 | 57 | 86 |
| 7 | 110 | 56 | 9 | 56 | 12 |
| 7 | 110 | 12 | 10 | 49 | 11 |

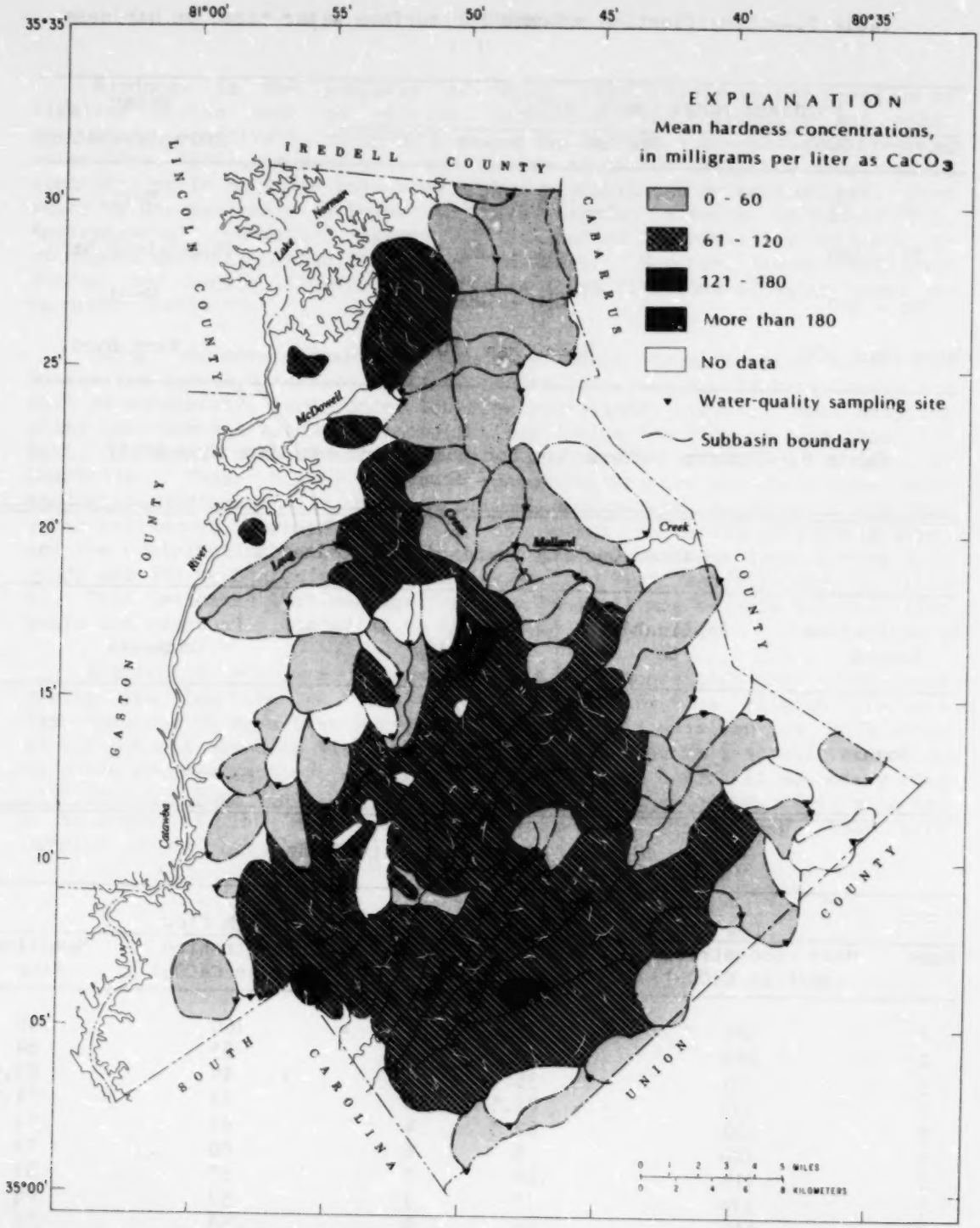



Figure 8.--Mean hardness concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

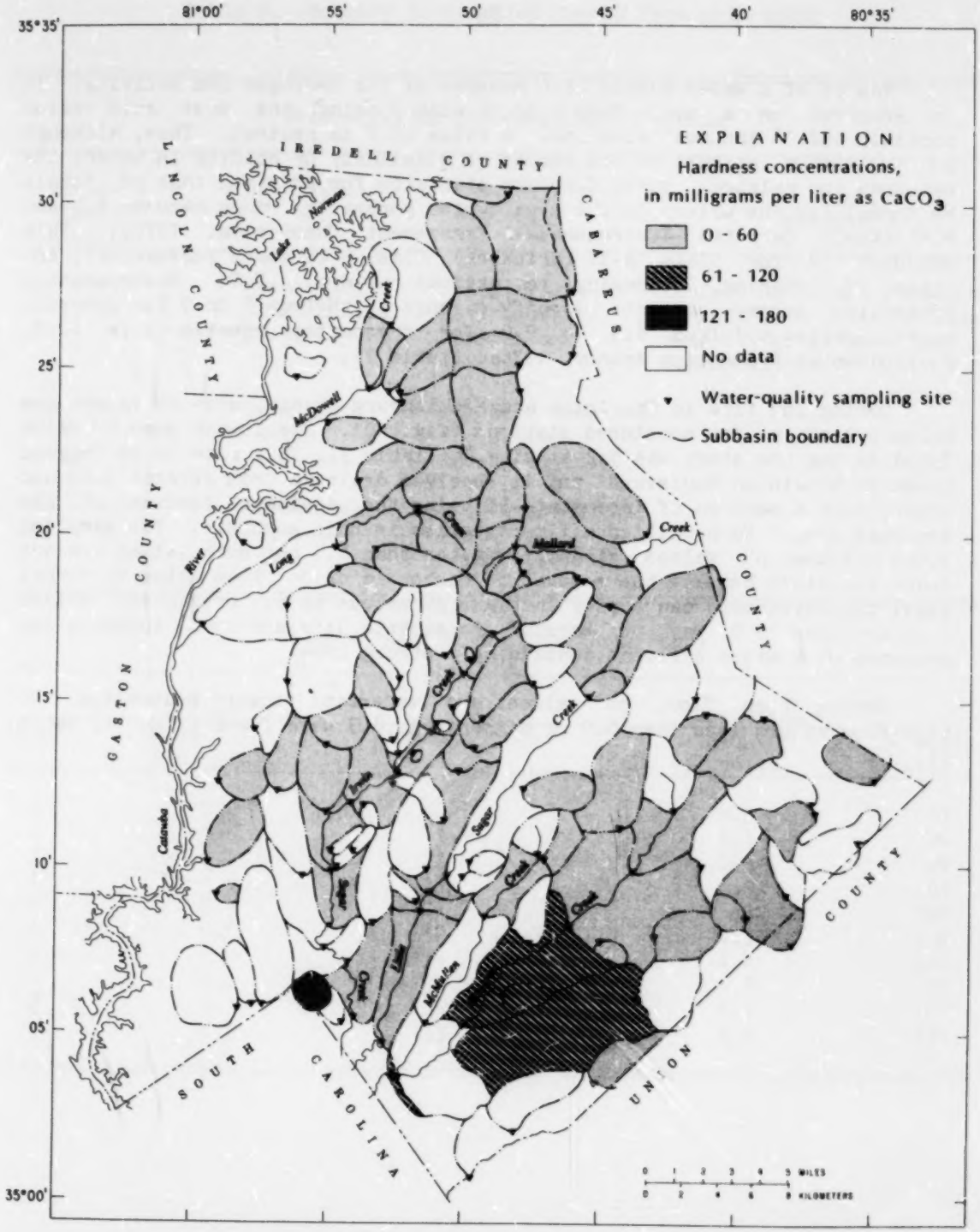



Figure 9.--Hardness concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## pH

The pH of a water sample is a measure of its hydrogen ion activity. It is measured on a scale from 0 to 14 with 0 being the most acid value possible and 14 the most alkaline. A value of 7 is neutral. Thus, although pH is not a measure of the amount of alkalinity or acidity in water, the measures are related. North Carolina standards for pH state that pH, "shall be normal for the waters in the area, which generally range between 6.0 and 8.5" (North Carolina Environmental Management Commission, 1979). This standard is for Class A-II (drinking), Class B (primary recreation), and Class C (fishing, secondary recreation) waters. U.S. Environmental Protection Agency criteria specify a range of pH from 5 to 9 for domestic water supplies and from 6.5 to 9.0 for freshwater aquatic life (U.S. Environmental Protection Agency, 1976a) (table 9).

During low flow in Charlotte and Mecklenburg County, mean pH values are below 6.0 at a few scattered stations (fig. 10). The lowest mean pH value found during the study was 5.2 at site 40 (table 9). This site is on Taggart Creek at Wilkinson Boulevard and it receives drainage from several land-use types, with a section of Interstate-85 being the dominant feature of the drainage area. No permitted effluents exist in this subbasin. Two sampling sites had mean pH values slightly greater than 8.5 but such values are not cause for alarm because the removal of carbon dioxide from water by normal algal photosynthesis can easily increase pH values to 8.5 or higher. Values greater than 9.0 may be harmful to aquatic life and could indicate the presence of a waste effluent containing a strong base.

During high flow, pH values are moderated toward neutrality. No high-flow values less than 6.0 or higher than 8.3 were found (fig. 11, table 9).

Table 9.--Summary information for pH from this study

Water-Quality Standards and Criteria

| Value limits (pH units) | Applicable to | Authority | Comments |
|---|---|---|---|
| 6.0 - 8.5 | Class A-II, Class B, and Class C. | North Carolina Environmental Commission (1979). | Standard is normal pH where normal for a water is less than 6.0 or greater than 8.5 pH units. |
| 5.0 - 9.0 | Domestic water supplies. | U.S. Environmental Protection Agengy (1976a). | |
| 6.5 - 9.0 | Freshwater aquatic life. | U.S. Environmental Protection Agency (1976a). | |

Lowest Mean Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean value (pH units) | Sampling site | Rank | Value (pH units) | Sampling site |
| 1 | 5.2 | 40 | 1 | 6.0 | 61 |
| 2 | 5.5 | 7 | 2 | 6.1 | 95 |
| 2 | 5.5 | 127 | 3 | 6.3 | 99 |
| 4 | 5.6 | 125 | 3 | 6.3 | 101 |
| 5 | 5.7 | 124 | 3 | 6.3 | 104 |
| 6 | 5.8 | 18 | 3 | 6.3 | 110 |
| 7 | 5.9 | 134 | 7 | 6.4 | 102 |
| 8 | 6.2 | 132.5 | 7 | 6.4 | 75 |
| 9 | 6.3 | 135 | 7 | 6.4 | 107 |
| 10 | 6.4 | 133 | 10 | 6.5 | 140 |

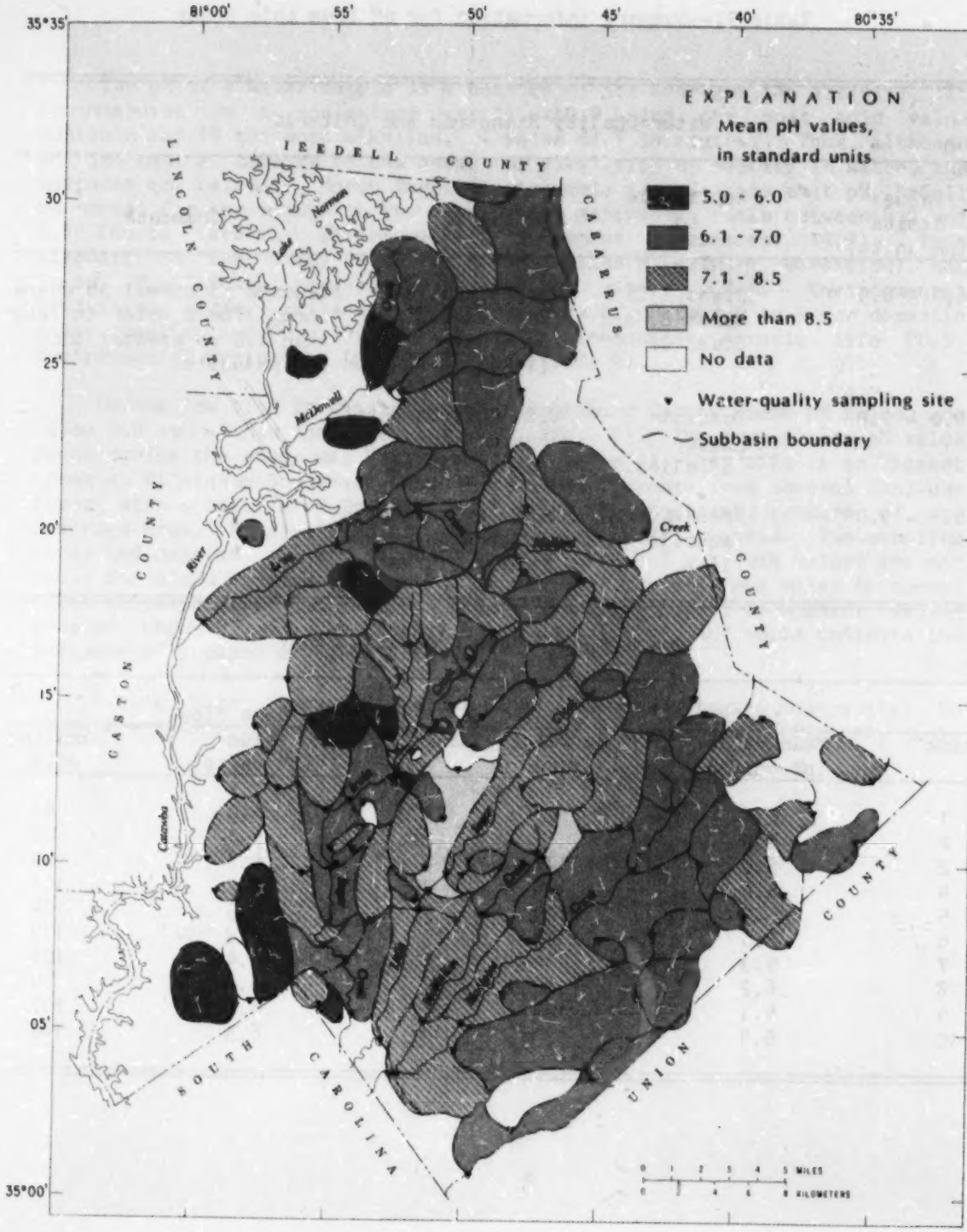



Figure 10.--Mean pH values during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

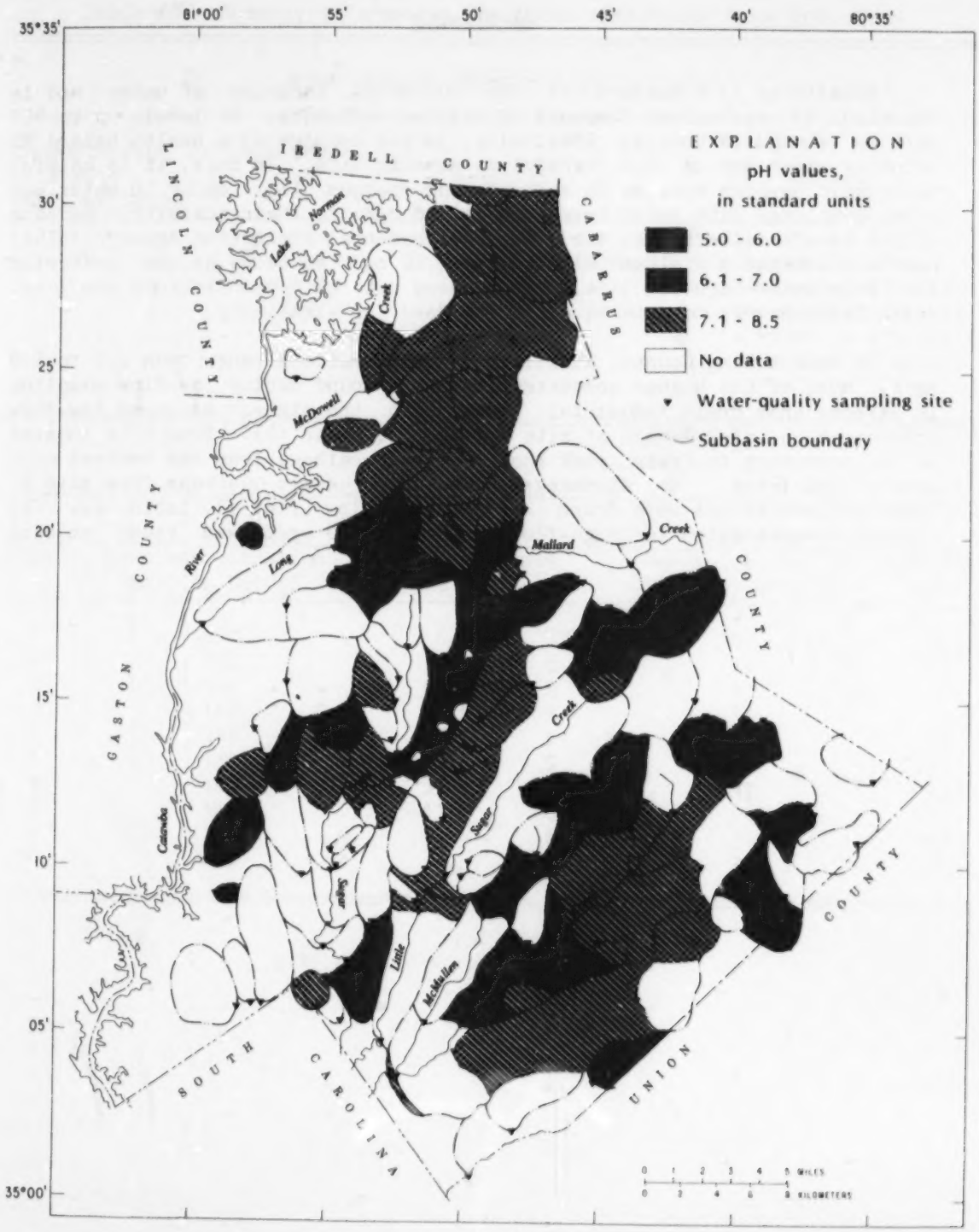



Figure 11.--pH values during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Alkalinity

Alkalinity is a measure of the buffering capacity of water, and is reported as equivalent amounts of calcium carbonate. At levels up to 400 mg/L as calcium carbonate, alkalinity is not considered a health hazard in drinking water and is not harmful to aquatic life. In fact, it is helpful to aquatic species because it moderates pH changes that occur in water and forms complexes with toxic heavy metals and reduces their toxicity. Because of its beneficial effects, the U.S. Environmental Protection Agency (1976a) has established a minimum alkalinity of 20 mg/L as $CaCO_3$ as the criterion for freshwater aquatic life, except where natural concentrations are less. North Carolina has no water-quality standard for alkalinity.

In Mecklenburg County, alkalinity concentrations range from 5.5 to 300 mg/L. Most of the higher concentrations were found during low-flow sampling in streams that drain industrial areas with the highest measured low-flow concentration of 300 mg/L at site 6 (fig. 12, table 10). Site 6 is located on a tributary to Irwin Creek that receives drainage from the central city area of Charlotte. No discharges are under permit upstream from site 6. Lower concentrations were found during high flow (fig. 13, table 10). The highest concentration for high-flow samples of 160 mg/L was found at site 35.

Table 10.--Summary information for total alkalinity from this study

Water-Quality Standards and Criteria

| Concentration limits (mg/L as $CaCO_3$) | Applicable to | Authority | Comments |
|---|---|---|---|
| 20 | Freshwater aquatic life. | U.S. Environmental Protection Agency (1976a). | Criterion is the natural alkalinity where alkalinity of a water is naturally less than 20 mg/L. |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L as $CaCO_3$) | Sampling site | Rank | Concentration (mg/L as $CaCO_3$) | Sampling site |
| 1 | 300 | 6 | 1 | 160 | 35 |
| 2 | 170 | 74.5 | 2 | 74 | 133 |
| 3 | 140 | 86 | 3 | 57 | 46 |
| 3 | 140 | 83.5 | 4 | 44 | 74.5 |
| 3 | 140 | 56.5 | 5 | 42 | 76 |
| 6 | 120 | 2 | 5 | 42 | 138 |
| 6 | 120 | 57 | 7 | 37 | 91 |
| 6 | 120 | 41 | 8 | 36 | 81 |
| 6 | 120 | 11 | 8 | 36 | 84 |
| 10 | 110 | 5 | 8 | 36 | 21 |

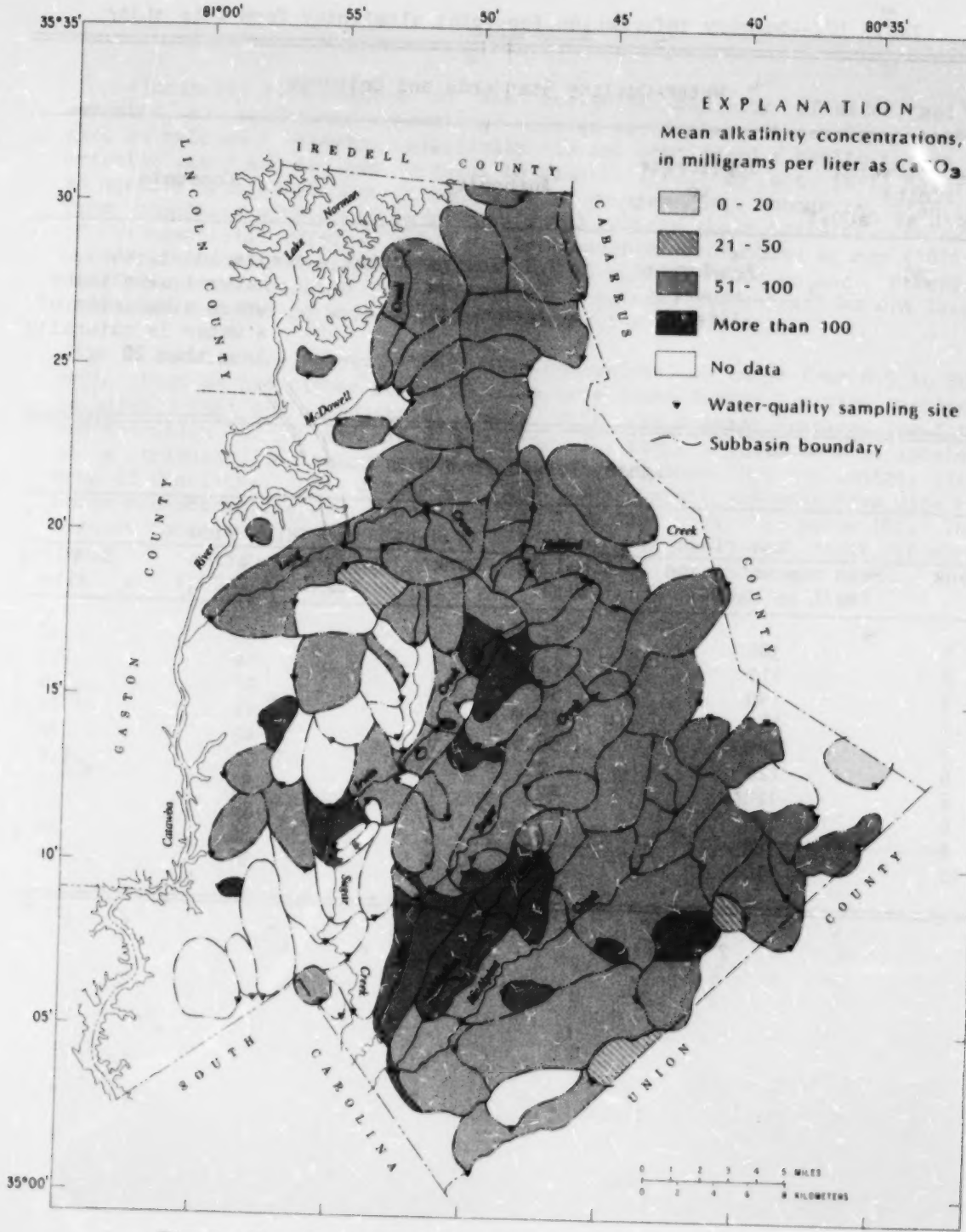



Figure 12.--Mean alkalinity concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

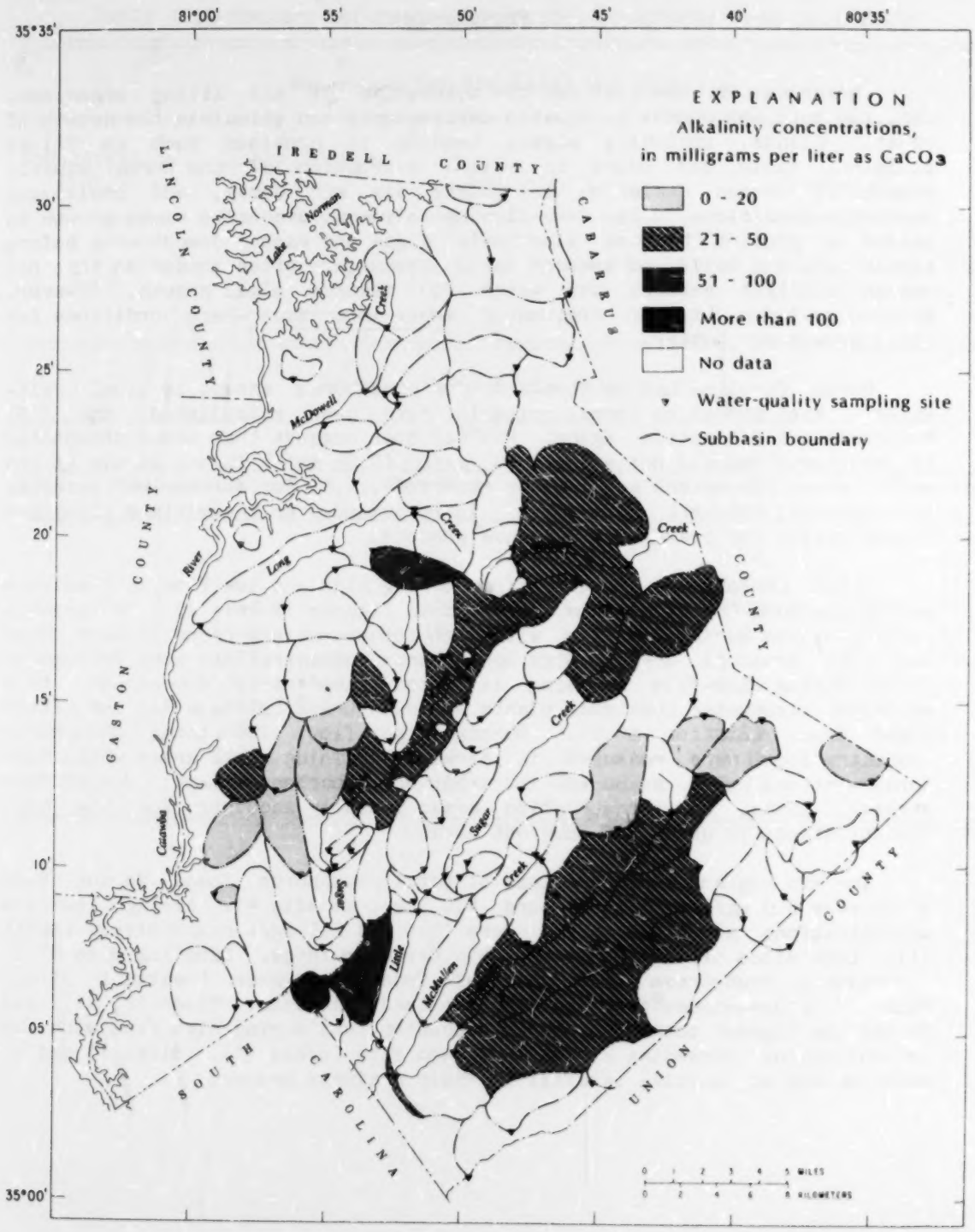



Figure 13.--Alkalinity concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Phosphorus

Phosphorus is essential for the metabolism of all living organisms. Yet, too much phosphorus in aquatic environments can stimulate the growth of aquatic plants, including algae, leading to problems such as filter clogging, taste and odors in water, disruption of the normal aquatic community, oxygen depletion as plants die and decay, and unpleasant aesthetic conditions. In free-flowing streams, excessive algal growth is seldom a problem because planktonic algae are washed downstream before populations can build and because small streams are often shaded so that not enough sunlight reaches the water for maximum algal growth. However, phosphorus-laden streams frequently empty into lakes where conditions for algal growth are better.

North Carolina has no standard for phosphorus except in tidal saltwater. Even though no formal criteria have been established, the U.S. Environmental Protection Agency (1976a) does suggest that total phosphates as phosphorus "should not exceed 50 µg/L (0.05 mg/L) in any stream at the point where it enters any lake or reservoir...." For streams not entering impoundments, 100 µg/L (0.1 mg/L) is recommended as the maximum phosphate concentration for preventing nuisance growths.

Total phosphorus concentrations during high and low flow in Charlotte and Mecklenburg County streams are shown in figures 14 and 15. A variable pattern exists during low flow, with high concentrations found in both urban and rural drainage areas. High phosphorus concentrations were frequently found during low-flow sampling at sites immediately downstream from municipal wastewater treatment plants on Irwin Creek (station 41) and Little Sugar Creek (Station 56.5). During high flow, low total phosphorus concentrations were measured in streams draining rural areas while high concentrations were measured in urban and suburban streams. Runoff from streets, lawns, and construction areas probably accounts for the high concentrations in urban and suburban areas.

The two highest concentrations of total phosphorus found during this study were 5.0 mg/L at site 21 and 4.0 mg/L at site 41. Average low-flow concentrations at these sites were 1.9 and 2.5 mg/L respectively (table 11). Both sites are in the Sugar-Irwin Creek drainage. Sampling site 41 is immediately downstream from the Irwin Creek wastewater treatment plant. Site 21 is downstream from two inactive landfill sites. Sites 12, 11, and 24 had the highest total phosphorus concentrations during high flow with the concentrations exceeding 2.0 mg/l at each site (table 11). Sites 11 and 12 each include an inactive landfill in their drainage basins.

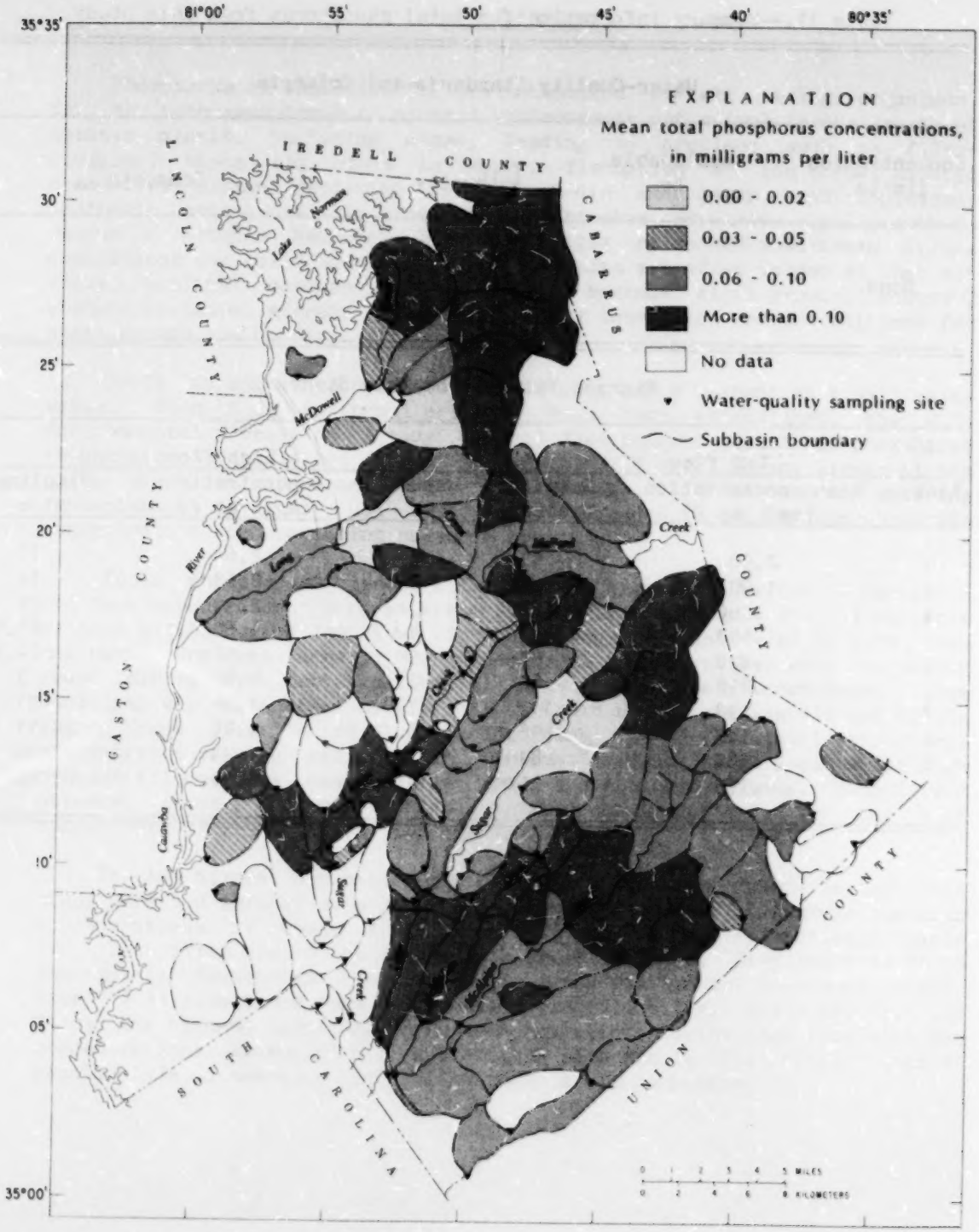
Table 11.--Summary information for total phosphorus from this study

Water-Quality Standards and Criteria

| Concentration limits | Applicable to | Authority | Comments |
|---|---|---|---|
| None | | | |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L as P) | Sampling site | Rank | Concentration (mg/L as P) | Sampling site |
| 1 | 2.50 | 41 | 1 | 2.64 | 12 |
| 2 | 1.90 | 21 | 2 | 2.63 | 11 |
| 3 | .460 | 124.5 | 3 | 2.30 | 24 |
| 4 | .440 | 133 | 4 | 1.60 | 83.5 |
| 5 | .216 | 57 | 5 | 1.56 | 74.5 |
| 5 | .216 | 60 | 6 | 1.50 | 3 |
| 7 | .190 | 117 | 7 | 1.45 | 21 |
| 8 | .180 | 56.5 | 8 | 1.44 | 41 |
| 8 | .180 | 81 | 9 | 1.34 | 76 |
| 10 | .175 | 5 | 10 | 1.30 | 60 |


81°00'
55'
50'
45'
40'
80°35'
35°35'
30'
25'
20'
15'
10'
05'
35°00'
EXPLANATION
Mean total phosphorus concentrations, in milligrams per liter
0.00 - 0.02
0.03 - 0.05
0.06 - 0.10
More than 0.10
No data
Water-quality sampling site
Subbasin boundary
IREDELL COUNTY
LINCOLN COUNTY
CABARRUS COUNTY
GASTON COUNTY
SOUTH CAROLINA
UNION COUNTY
Lake Norman
Lake
McDowell
Creek
Sugar
Clarke
Creek
Creek
Creek

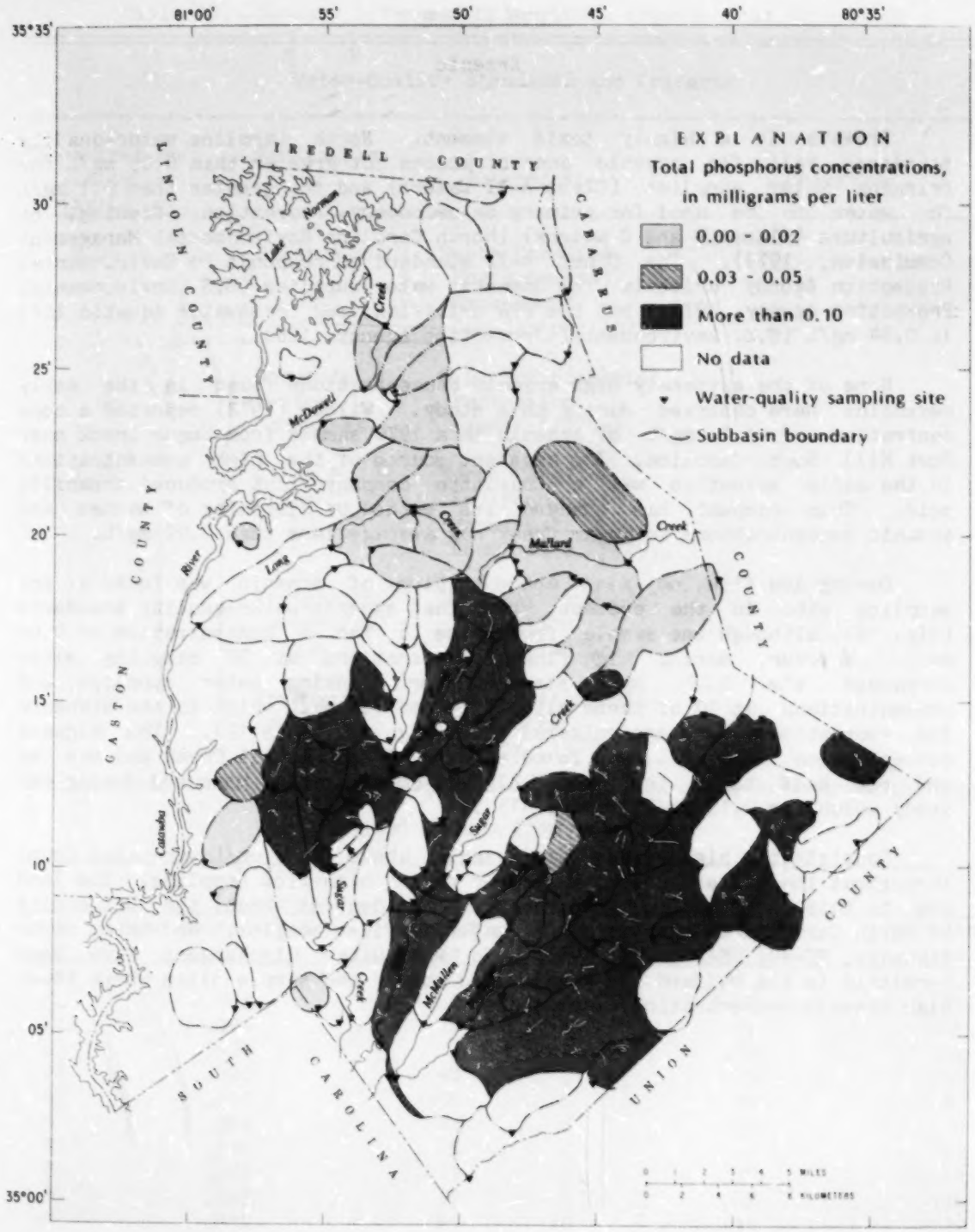



Figure 15.--Total phosphorus concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Trace Elements

### Arsenic

Arsenic is a highly toxic element. North Carolina water-quality standards call for arsenic concentrations not greater than 0.05 mg/L for drinking water supplies (Class A-II waters) and not greater than 0.1 mg/L for water to be used for primary or secondary recreation, fishing, or agriculture (Class B and C waters) (North Carolina Environmental Management Commission, 1979). The Class A-II standard corresponds to Environmental Protection Agency criteria for domestic water supplies (U.S. Environmental Protection Agency, 1976a) but the EPA criterion for freshwater aquatic life is 0.44 mg/L (U.S. Environmental Protection Agency, 1980).

None of the extremely high arsenic concentrations found in the early seventies were observed during this study. Wilder (1972) reported a concentration of 1.1 mg/L of arsenic in a 1970 sample from Sugar Creek near Fort Mill, South Carolina. The apparent source of the high concentrations in the early seventies was a Charlotte company that produced arsanilic acid. This company has changed its method of disposing of wastes and arsenic concentrations in Sugar Creek now average less than 0.02 mg/L.

During low flow, no mean concentration of arsenic was found at any sampling site in the present study that exceeds water-quality standards (fig. 16), although one sample from site 6 had a concentration of 0.06 mg/L. However, during high flow, concentrations at 20 sampling sites surpassed the 0.05 mg/L standard for drinking water supplies and concentrations at 10 of these sites exceeded 0.1 mg/L which is the standard for recreational and agricultural uses (fig. 17, table 12). The highest concentration, 0.48 mg/L, was found at site 75 on Campbell Creek and was two and one half times the second highest concentration measured during the study which was 0.19 mg/L at site 115.5.

Consistently high values of arsenic above 0.1 mg/L were also found throughout the Mallard Creek watershed during high-flow sampling. The land use in this watershed includes rural and residential areas, the University of North Carolina at Charlotte, a major office complex, and three major highways, NC-49, US-29, and I-85. No wastewater dischargers have been permitted in the Mallard Creek watershed above the sample sites where these high arsenic concentrations were found.

Table 12.--Summary information for total arsenic from this study

Water-Quality Standards and Criteria

| Concentration limits (mg/L) | Applicable to | Authority | Comments |
|---|---|---|---|
| 0.05 | Class A-II | North Carolina Environmental Management Commission (1979). | |
| | Domestic water supplies. | U.S. Environmental Protection Agency (1976a). | |
| 0.10 | Class B, Class C. | North Carolina Environmental Management Commission (1979). | |
| | Irrigation water for crops. | U.S. Environmental Protection Agency (1976a). | |
| 0.44 | Freshwater aquatic life. | U.S. Environmental Protection Agency (1976a). | |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L) | Sampling site | Rank | Concentration (mg/L) | Sampling site |
| 1 | 0.023 | 21 | 1 | 0.48 | 75 |
| 2 | .020 | 18 | 2 | .19 | 115.5 |
| 2 | .020 | 7 | 3 | .18 | 112 |
| 2 | .020 | 40 | 3 | .18 | 119 |
| 5 | .017 | 107 | 5 | .16 | 42 |
| 5 | .017 | 41 | 6 | .13 | 24 |
| 7 | .016 | 6 | 7 | .12 | 95 |
| 8 | .015 | 111 | 7 | .12 | 114 |
| 8 | .015 | 15 | 7 | .12 | 108 |
| 10 | .011 | 81 | 10 | .10 | 129 |

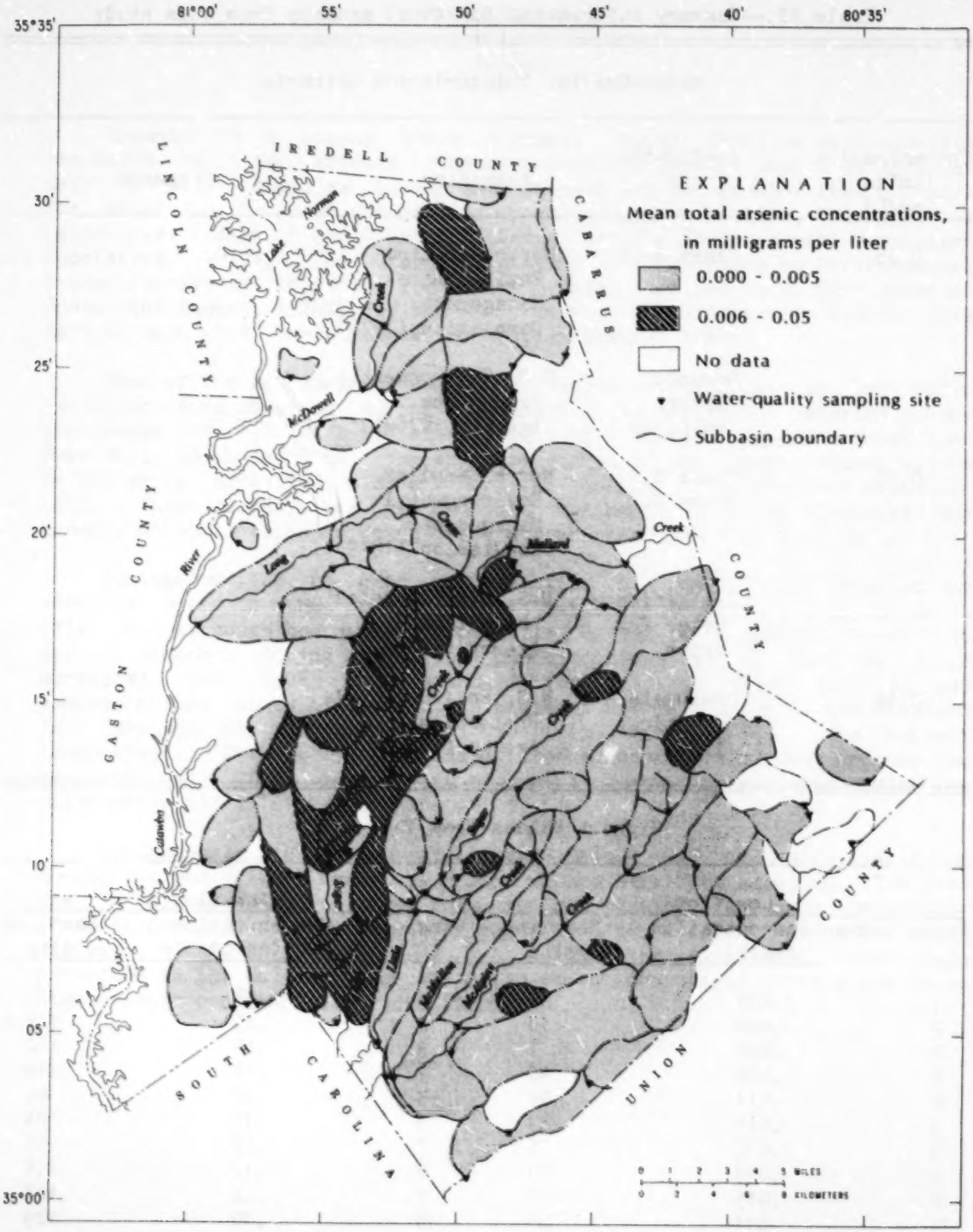



Figure 16.--Mean total arsenic concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

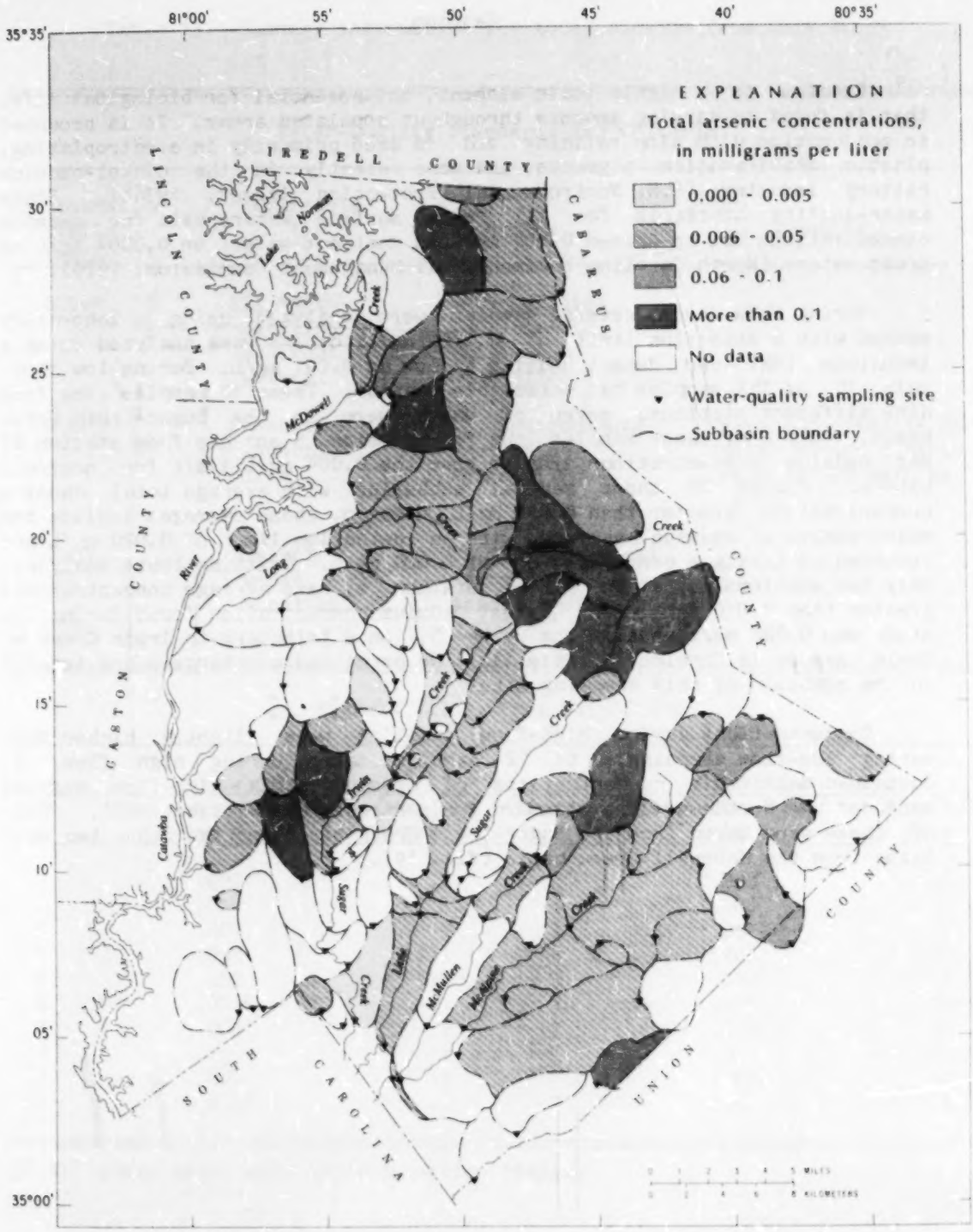



Figure 17.--Total arsenic concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Cadmium

Cadmium is a highly toxic element, not essential for biological life, that is found in varying amounts throughout populated areas. It is produced in conjunction with zinc refining and is used primarily in electroplating, plastic stabilization, pigments, and more recently in the nickel-cadmium battery industry (U.S. Environmental Protection Agency, 1976b). State water-quality standards for all fresh surface waters call for cadmium concentrations not to exceed 0.004 mg/L in nontrout waters or 0.0004 mg/L in trout waters (North Carolina Environmental Management Commission, 1979).

During this study, several samples were analyzed using a laboratory method with a detection limit of 0.020 mg/L; others were analyzed using a technique that can detect cadmium as low as 0.001 mg/L. During low flow, only 10 of 153 samples had detectable cadmium. These 10 samples came from nine different stations, seven of which were in the Sugar-Irwin Creek basin. Only 2 of these samples (one from station 5 and one from station 6) had cadmium concentrations greater than the 0.004 mg/L limit for nontrout waters. Figure 18 shows several subbasins with average total cadmium concentrations greater than 0.010 mg/L. However, these averages include the measurements of cadmium analyzed with a detection limit of 0.020 mg/L and recorded as having a concentration of 0.020 mg/L. Omitting these analyses, only two stations, station 5 and station 6, have average concentrations greater than 0.010 mg/L. The highest cadmium concentration found during the study was 0.022 mg/L at sampling site 5, on a tributary to Irwin Creek at Irwin Avenue in Charlotte (table 13). No permitted dischargers are located in the subbasin of this sampling site.

Concentrations during high-flow sampling were slightly higher than during low-flow sampling. Of 72 samples taken during high flow, 21 contained detectable concentrations of cadmium. Six high-flow samples exceeded the North Carolina standard for nontrout waters (table 13). Four of these were taken from the Sugar-Irwin Creek basin and the other two were taken from the McDowell Creek basin (fig. 19).

Table 13.--Summary information for total cadmium from this study

Water-Quality Standards and Criteria

| Concentration limits (mg/L) | Applicable to | Authority | Comments |
|---|---|---|---|
| 0.004 | All North Carolina nontrout waters. | North Carolina Environmental Management Commission (1979). | |
| 0.003 | Freshwater aquatic life. | U.S. Environmental Protection Agency (1980). | Criterion cited is for water having a hardness of 100 mg/L as $CaCO_3$. |
| 0.01 | Domestic water supplies. | U.S. Environmental Protection Agency (1976a). | |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L) | Sampling site | Rank | Concentration (mg/L) | Sampling site |
| 1 | 0.022 | 5 | 1 | 0.008 | 126 |
| 2 | .018 | 6 | 1 | .008 | 17 |
| 3 | .004 | 9 | 3 | .007 | 24 |
| 4 | .003 | 113 | 3 | .007 | 125 |
| 5 | .002 | 134 | 3 | .007 | 11 |
| 6 | .0015 | 21 | 3 | .007 | 12 |
| 7 | .001 | 2 | 7 | .003 | 95 |
| 7 | .001 | 11 | 7 | .003 | 41 |
| 7 | .001 | 12 | 7 | .003 | 46 |
| 10 | --[1/] | -- | 7 | .003 | 6 |

[1/] All other sites were below detection limits.

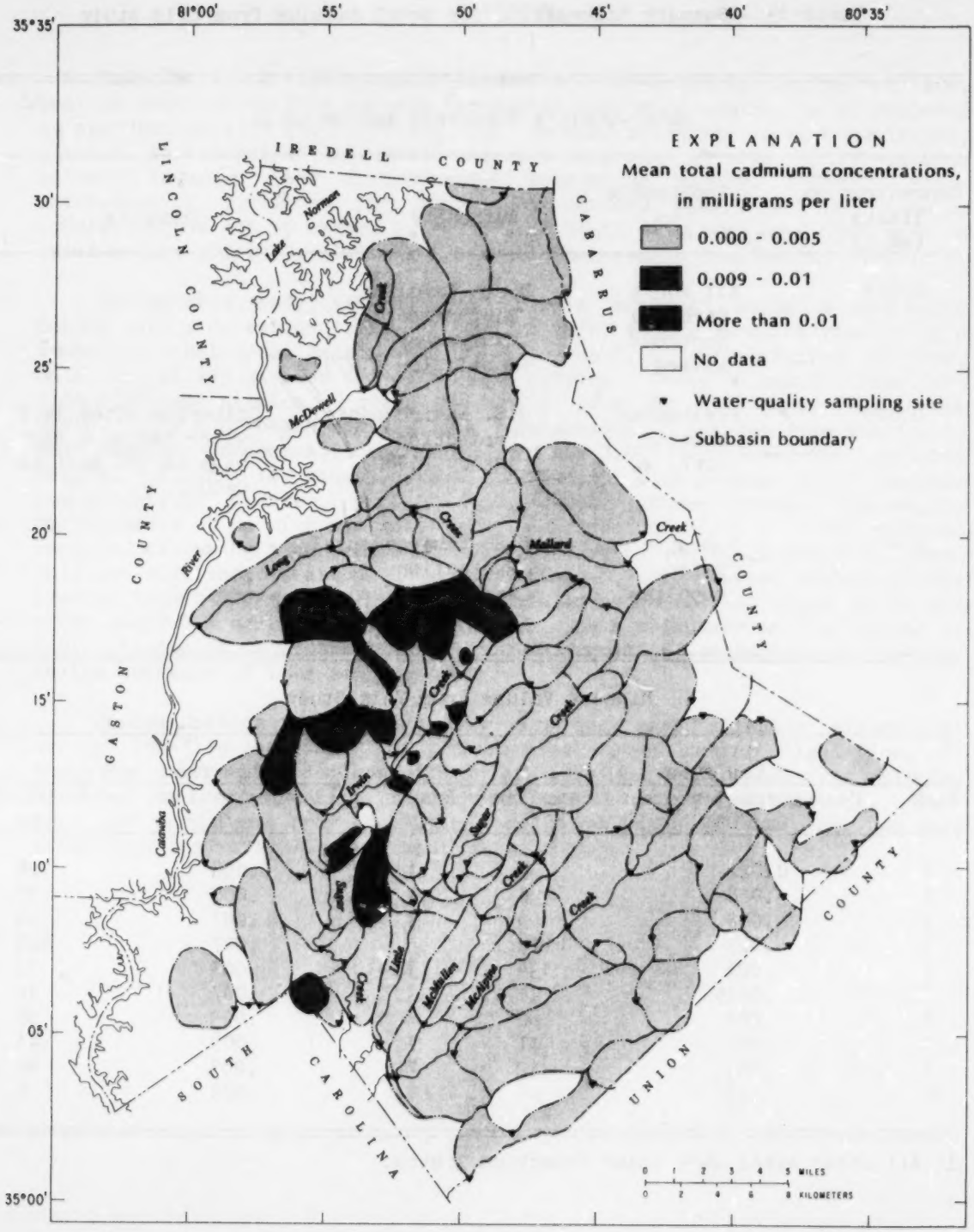



Figure 18.--Mean total cadmium concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

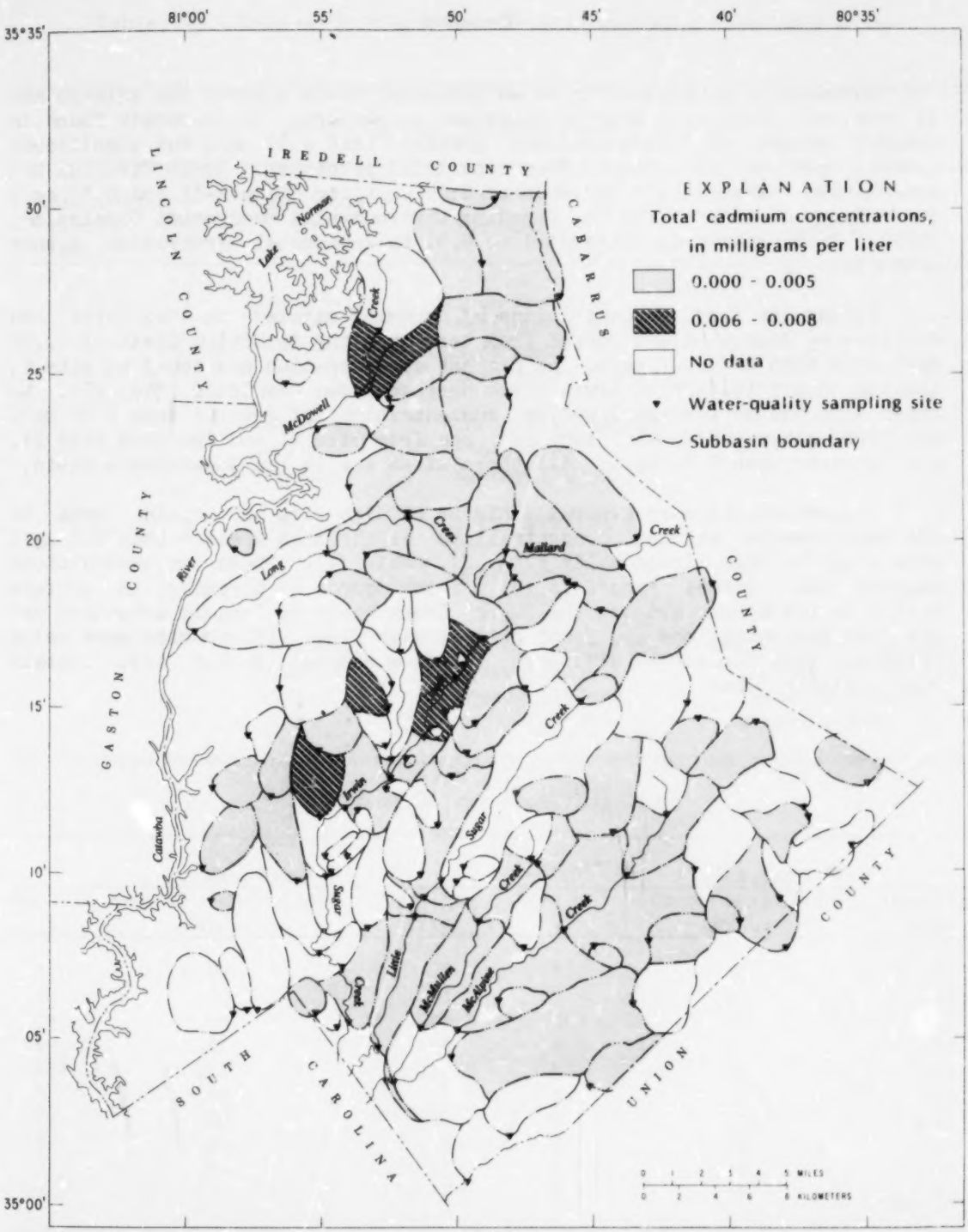



Figure 19.--Total cadmium concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Chromium

Chromium is considered to be an essential trace element for animals and is not as toxic as arsenic, cadmium, or mercury. It is rarely found in natural waters at concentrations greater than 0.01 mg/L but significant amounts can be introduced from industrial processes. North Carolina has established standards for chromium of 0.05 mg/L for Class A-II and 0.10 mg/L for Class C waters (North Carolina Environmental Management Commission, 1979). These standards correspond to U.S. Environmental Protection Agency criteria.

During low flow, concentrations of chromium sampled in Charlotte and Mecklenburg County waters ranged from less than the detection limit of 0.001 mg/L to a high of 0.37 mg/L. The highest concentration was found at site 6, located on a tributary of Irwin Creek near downtown Charlotte (fig. 20). No other site had an average low-flow concentration of greater than 0.10 mg/L but three other individual samples, one from site 41 and two from site 21, were greater than 0.10 mg/L. All these sites are in the Sugar-Irwin basin.

Concentrations were generally higher at high flow and again, most of the measurements showing concentrations of chromium greater than 0.1 mg/L were from the Sugar-Irwin basin (fig. 21, table 14). These two observations suggest that street runoff is the primary source of chromium in surface waters in the County because the Sugar Creek basin is largely urbanized and the high concentrations are found only at high flow. If chromium were being released from industrial effluents, low-flow samples should also contain high concentrations.

Table 14.--Summary information for total chromium from this study

Water-Quality Standards and Criteria

| Concentration limits (mg/L) | Applicable to | Authority | Comments |
|---|---|---|---|
| 0.05 | Class A-II | North Carolina Environmental Management Commission (1979). | |
| | Domestic water supplies. | U.S. Environmental Protection Agency (1976a). | |
| 0.10 | Class C | North Carolina Environmental Management Commission (1979). | |
| | Freshwater aquatic life. | U.S. Environmental Protection Agency (1976a). | New criteria issued in 1980 by EPA are based on valence of chromium ion. |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L) | Sampling site | Rank | Concentration (mg/L) | Sampling site |
| 1 | 0.20 | 6 | 1 | 0.59 | 14 |
| 2 | .10 | 21 | 2 | .45 | 17 |
| 3 | .09 | 41 | 3 | .44 | 133 |
| 4 | .06 | 129 | 4 | .43 | 41 |
| 4 | .06 | 132.5 | 5 | .39 | 11 |
| 6 | .05 | 9.5 | 5 | .39 | 21 |
| 7 | .04 | 12 | 7 | .33 | 24 |
| 7 | .04 | 5 | 8 | .20 | 104 |
| 7 | .04 | 11 | 9 | .18 | 95 |
| 7 | .04 | 2 | 10 | .17 | 12 |

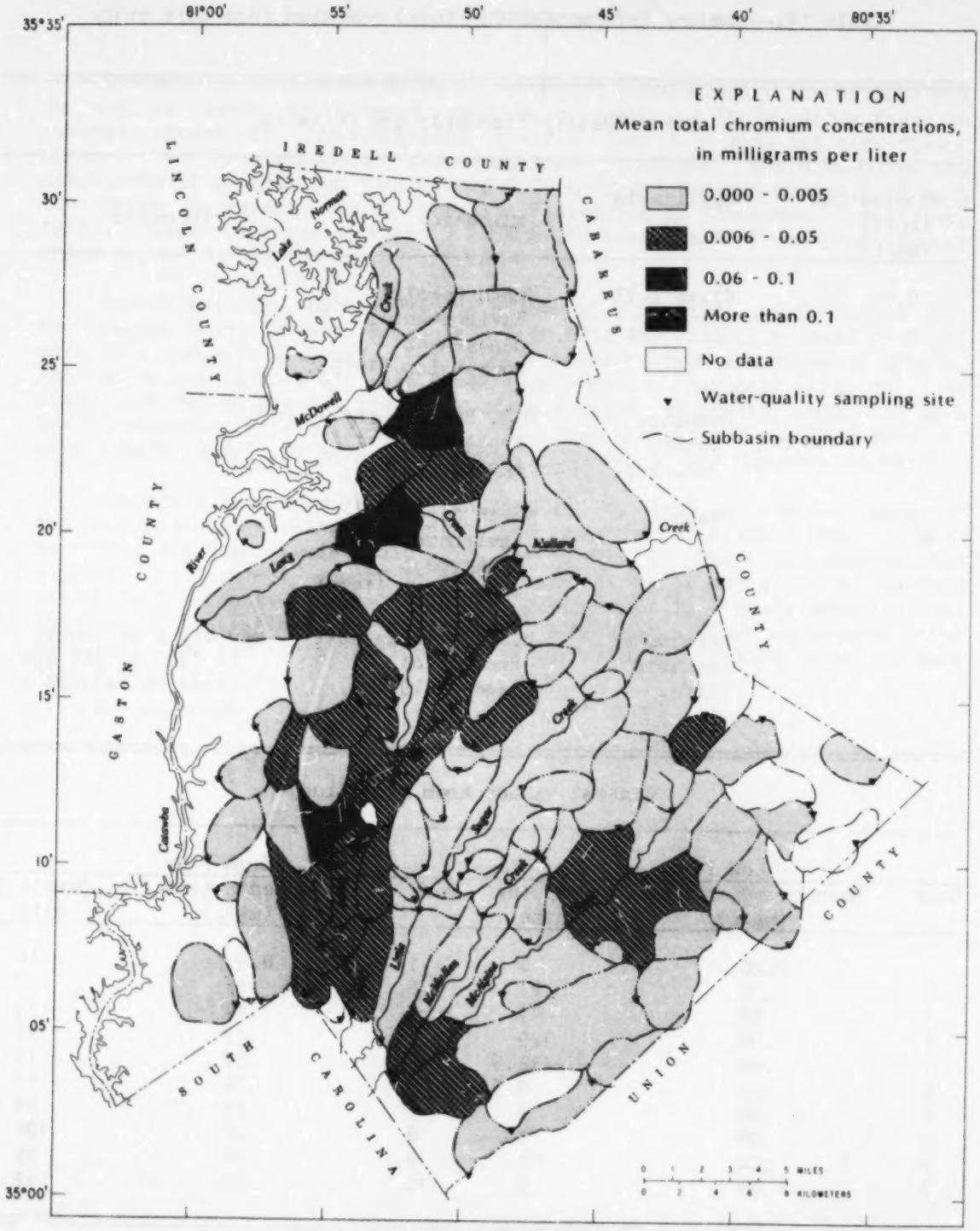



Figure 20.--Mean total chromium concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

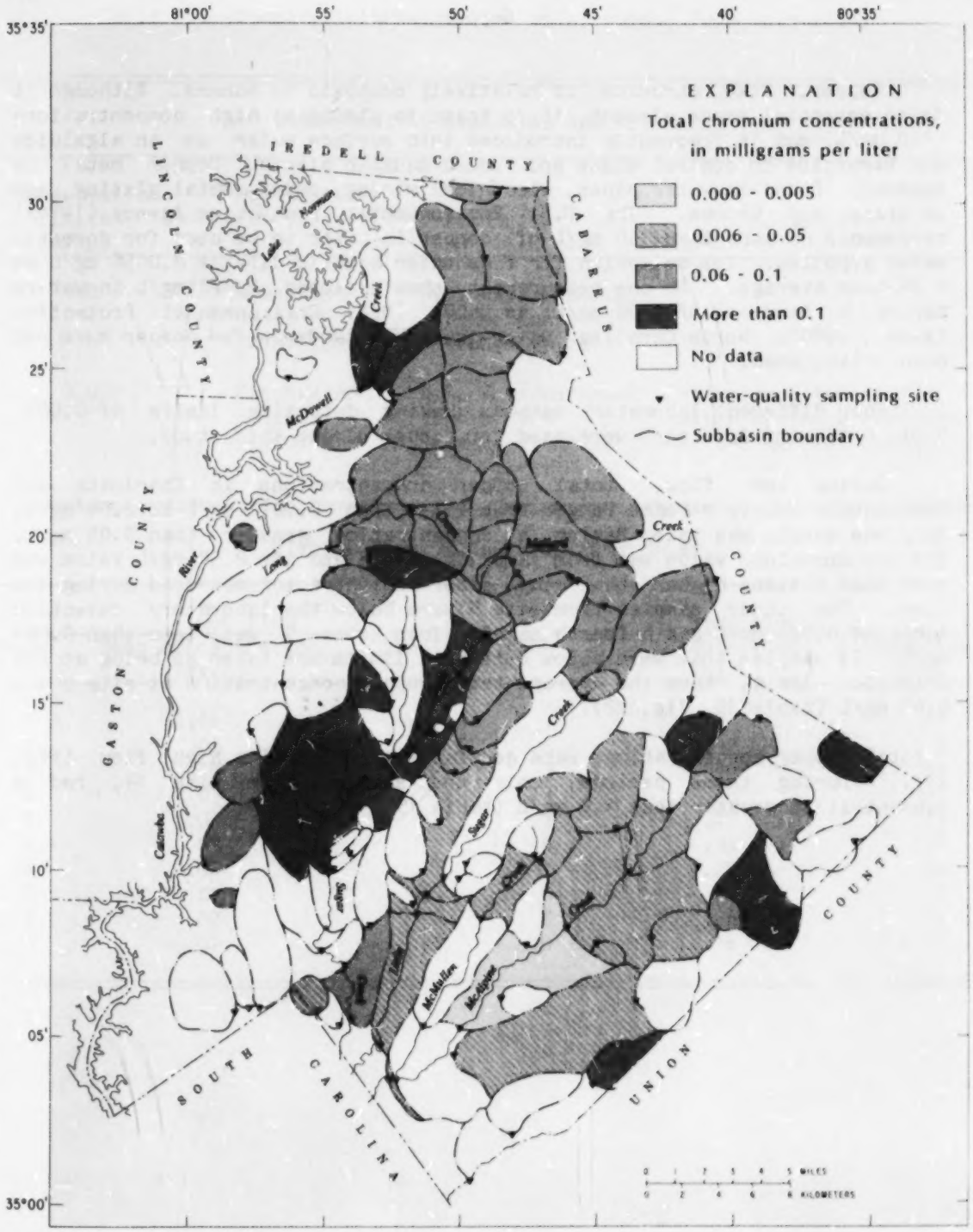



Figure 21.--Total chromium concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Copper

Copper, like chromium, is relatively nontoxic to humans. Although it is an essential trace element, it is toxic to plants at high concentrations (1.0 mg/L) and is frequently introduced into surface water as an algalcide and herbicide to control algae and rooted aquatic plants. Copper metal is commonly found in water pipes, electrical wiring, coins, metal plating, and in brass and bronze. The U.S. Environmental Protection Agency (1976a) recommends no more than 1.0 mg/L of copper in water to be used for domestic water supplies. The criterion for freshwater aquatic life is 0.0056 mg/L as a 24-hour average. No one measurement should exceed 0.022 mg/L in waters having a hardness of 100 mg/L as $CaCO_3$ (U.S. Environmental Protection Agency, 1980). North Carolina water-quality standards for copper have not been established.

Four different laboratory methods having detection limits of 0.001, 0.01, 0.02, and 0.05 mg/L were used for copper during this study.

During low flow, total copper concentrations in Charlotte and Mecklenburg County streams ranged from less than 0.001 mg/L to 2.54 mg/L. Only one sample was taken having a concentration greater than 0.05 mg/L. The one anomalous value was from sampling site 5 and its 2.54 mg/L value was more than 5 times higher than any other concentration measured during low flow. Two other samples from site 5 were below the laboratory detection limit of 0.020 mg/L and a fourth sample from site 5 was less than 0.001 mg/L. If samples that were below detection limits are taken as being at the detection limit, then the average total copper concentration at site 5 was 0.65 mg/L (table 15, fig. 22).

Total copper concentrations were generally higher during high flow (fig. 23). During these periods, only one sample, from site 14, had a concentration greater than 1.0 mg/L (table 15).

Table 15.--Summary information for total copper from this study

Water-Quality Standards and Criteria

| Concentration limits (mg/L) | Applicable to | Authority | Comments |
|---|---|---|---|
| 1.0 | Domestic water supplies. | U.S. Environmental Protection Agency (1976a). | |
| 0.022 | Freshwater aquatic life. | U.S. Environmental Protection Agengy (1980). | Criterion cited is for water having a hardness of 100 mg/L as $CaCO_3$. |

Highest Mean Values From This Study

| | Low flow | | | High flow | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L) | Sampling site | Rank | Concentration (mg/L) | Sampling site |
| 1 | 0.65 | 5 | 1 | 2.4 | 14 |
| 2 | .05 | 9.5 | 2 | .92 | 3 |
| 3 | .04 | 9 | 3 | .46 | 41 |
| 4 | .03 | 21 | 4 | .43 | 21 |
| 4 | .03 | 41 | 5 | .42 | 11 |
| 4 | .03 | 11 | 6 | .30 | 128 |
| 4 | .03 | 2 | 7 | .27 | 86 |
| 8 | .02 | 3 | 8 | .26 | 17 |
| 8 | .02 | 8 | 8 | .26 | 12 |
| 8 | .02 | 18 | 10 | .18 | 25 |

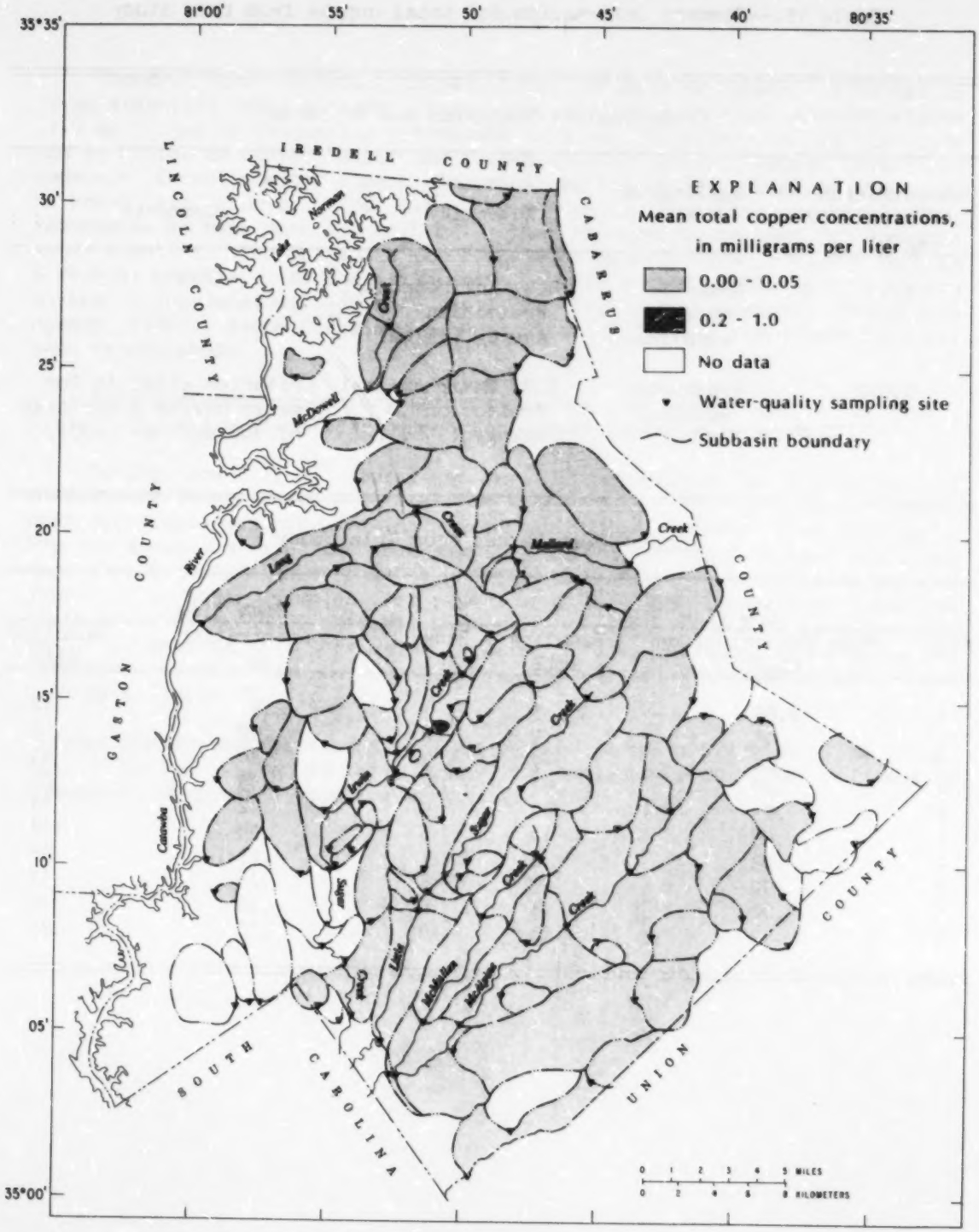



Figure 22.--Mean total copper concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

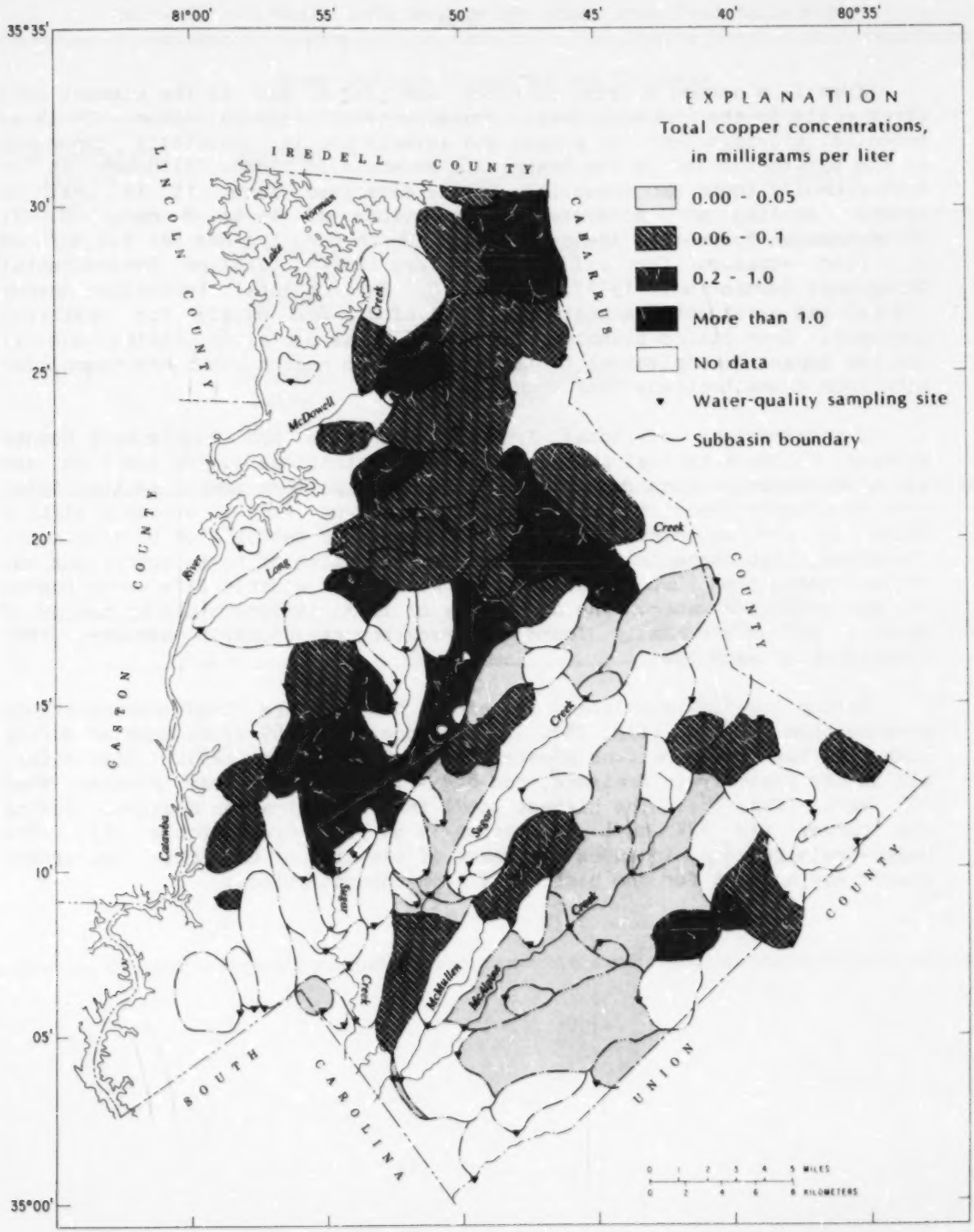



Figure 23.--Total copper concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Iron

Iron is a common element in rocks and soils and is the element that gives soils in the Piedmont their characteristic reddish color. It is an essential micronutrient for plants and animals and is especially important as the oxygen carrier in the hemoglobin molecule of blood. Although it is both commonly found and essential, in the dissolved form, it is toxic to aquatic species at moderate concentrations of 1 to 2 mg/L (U. S. Environmental Protection Agency, 1976a). North Carolina has set 1.0 mg/L as the iron standard for all surface waters (North Carolina Environmental Management Commission, 1979). The U.S. Environmental Protection Agency (1976a) has established a criterion level of 0.3 mg/L purely for aesthetic purposes. Iron stains plumbing fixtures such as porcelain, stains laundry, and can impart an unpleasant taste to water. No health risks are associated with iron concentrations less than 1.0 mg/L.

Concentrations of total iron in Charlotte and Mecklenburg County streams follow a typical pattern of low concentrations during low flow and elevated concentrations during high flow. This pattern indicates that total iron is closely associated with suspended sediment and is probably tightly bound to the sediment. This iron is removed by settling or by treatment. Therefore, high concentrations may not be indicative of toxic conditions but reflect total iron that is largely unavailable to aquatic life or to humans who may drink the water. The solubility of iron is determined by the pH of water. At pH's normally found in Mecklenburg County's streams, iron solubility is very low.

During low-flow sampling, 19 sites had average iron concentrations greater than 1.0 mg/L (fig. 24). All but one of the 69 sites sampled during high flow had concentrations greater than 1.0 mg/L (fig. 25). Six sites, all in the Sugar-Irwin drainage, had high-flow concentrations greater than 100 mg/L (fig. 25). The highest total iron concentration measured during the survey was 424 mg/L at station 14 on Irwin Creek (table 16). The Sugar-Irwin drainage includes the heart of the City of Charlotte and street runoff may account for the high total iron concentrations.

Table 16.--Summary information for total iron from this study

Water-Quality Standards and Criteria

| Concentration limits (mg/L) | Applicable to | Authority | Comments |
|---|---|---|---|
| 1.0 | All fresh surface waters. | North Carolina Environmental Management Commission (1979). | |
| 0.3 | Domestic water supplies. | U.S. Environmental Protection Agency (1976a). | |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L) | Sampling site | Rank | Concentration (mg/L) | Sampling site |
| 1 | 43.16 | 5 | 1 | 424.0 | 14 |
| 2 | 6.1 | 129 | 2 | 244.5 | 11 |
| 3 | 4.3 | 83 | 3 | 233.5 | 41 |
| 4 | 3.6 | 9 | 4 | 225.0 | 21 |
| 5 | 3.4 | 2 | 5 | 129.4 | 17 |
| 6 | 2.4 | 9.5 | 6 | 117.5 | 12 |
| 7 | 2.4 | 111 | 7 | 85.50 | 24 |
| 8 | 2.0 | 116 | 8 | 63.50 | 3 |
| 9 | 1.9 | 139 | 9 | 44.50 | 46 |
| 10 | 1.8 | 82 | 10 | 42.20 | 76 |

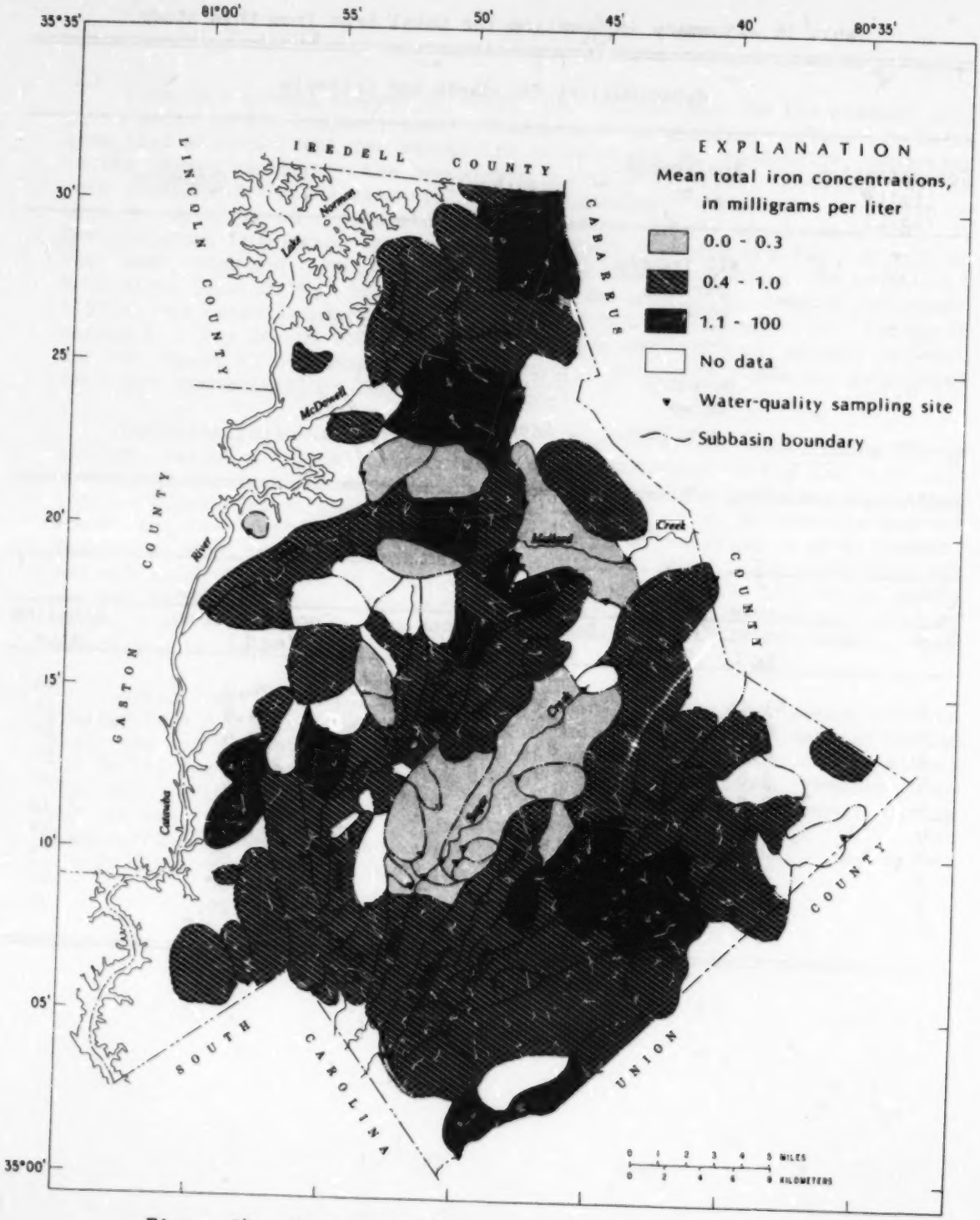



Figure 24.--Mean total iron concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

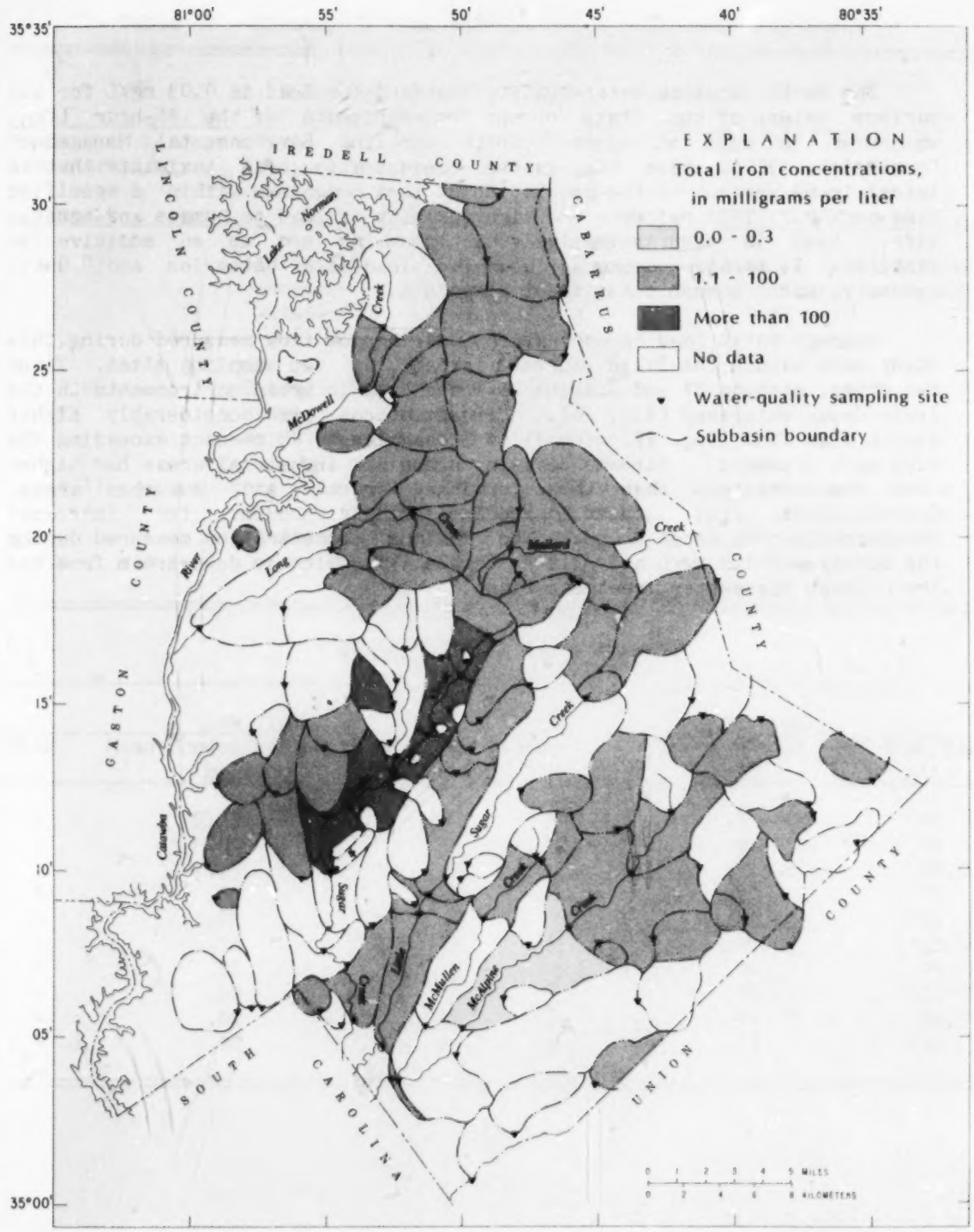



Figure 25.--Total iron concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Lead

The North Carolina water-quality standard for lead is 0.03 mg/L for all surface waters of the State or one one-hundredth of the 96-hour $LC_{50}$, whichever is more stringent (North Carolina Environmental Management Commission, 1979). (The $LC_{50}$ is the concentration of a toxicant that is lethal to 50 percent of the population of test organisms within a specified time period.) This reflects the high toxicity of lead to humans and aquatic life. Lead is used extensively in plumbing and is an additive for gasoline. It is also commonly used in lead-acid batteries and, until recently, was a common constituent in paints.

Average total lead concentrations during low flow measured during this study were within the State standard except at two sampling sites. These two sites, station 21 and station 5, are both in urban environments in the Irwin Creek watershed (fig. 26). Concentrations are considerably higher during high flow (fig. 27) with 31 of 72 samples or 43 percent exceeding the 0.03 mg/L standard. Streams draining urban and industrial areas had higher lead concentrations than those draining rural and suburban areas. Contributions from leaded gasoline probaly account for increased concentrations in urban areas. The maximum concentration measured during the survey was 1.3 mg/L at site 41 (table 17), which is downstream from the Irwin Creek Wastewater Treatment Plant.

Table 17.--Summary information for total lead from this study

Water-Quality Standards and Criteria

| Concentration limits (mg/L) | Applicable to | Authority | Comments |
|---|---|---|---|
| 0.03 | All fresh surface waters. | North Carolina Environmental Management Commission (1979). | Standard is (0.01)X(96-hr $LC_{50}$) if more stringent than 0.03 mg/L. |
| 0.05 | Domestic water supplies. | U.S. Environmental Protection Agency (1980). | |
| 0.17 | Freshwater aquatic life. | U.S. Environmental Protection Agency (1980). | Criterion cited is for water having a hardness of 100 mg/L as $CaCO_3$. |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L) | Sampling site | Rank | Concentration (mg/L) | Sampling site |
| 1 | 0.03 | 5 | 1 | 1.3 | 41 |
| 1 | .03 | 21 | 2 | .44 | 14 |
| 1 | .03 | 9 | 3 | .27 | 56.5 |
| 4 | .02 | 41 | 4 | .20 | 71 |
| 4 | .02 | 8 | 5 | .15 | 133 |
| 4 | .02 | 18 | 5 | .15 | 132.5 |
| 4 | .02 | 7 | 5 | .15 | 55 |
| 4 | .02 | 40 | 5 | .15 | 21 |
| 4 | .02 | 15 | 9 | .14 | 52.5 |
| 4 | .02 | 1 | 10 | .13 | 134 |

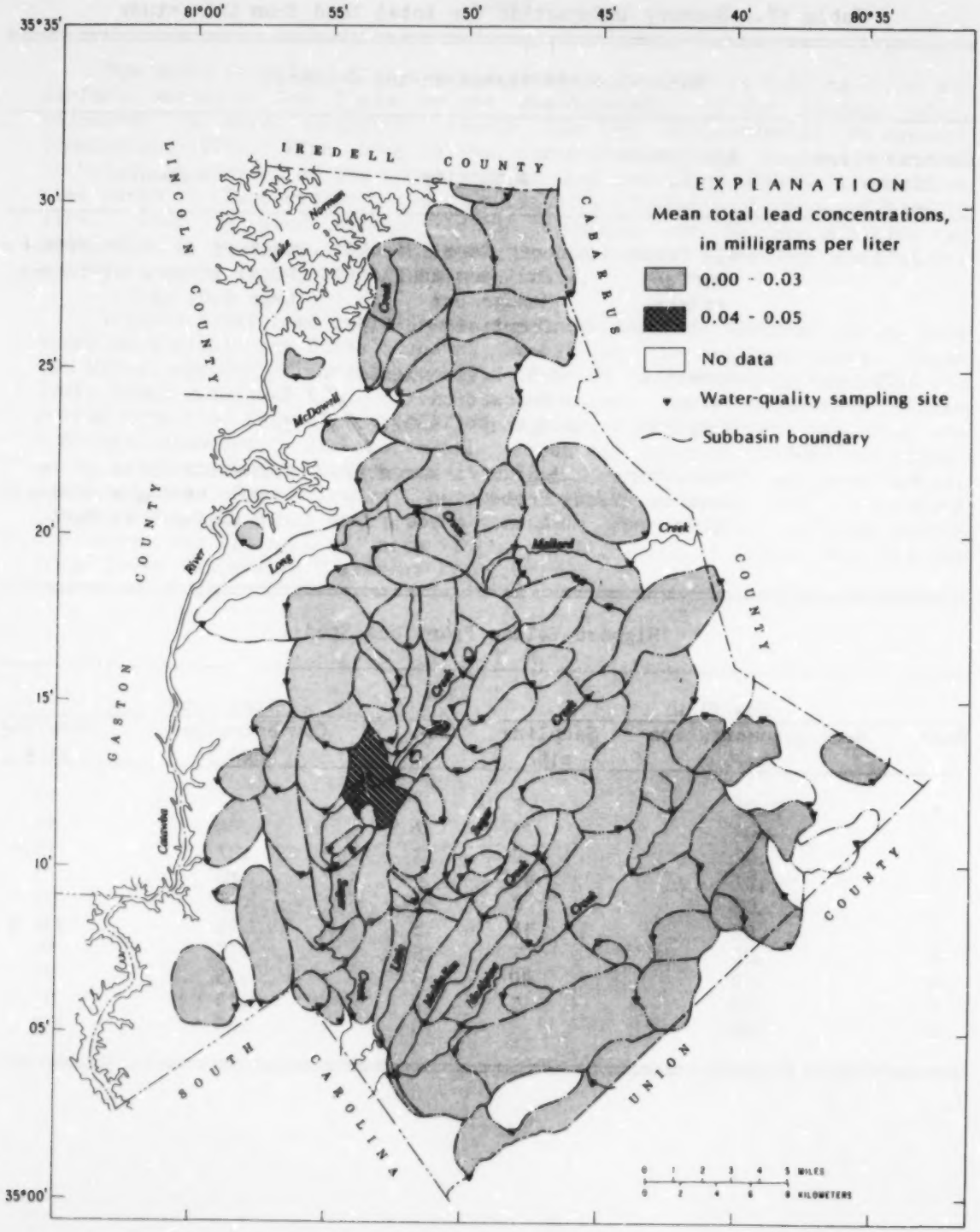



Figure 26.--Mean total lead concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

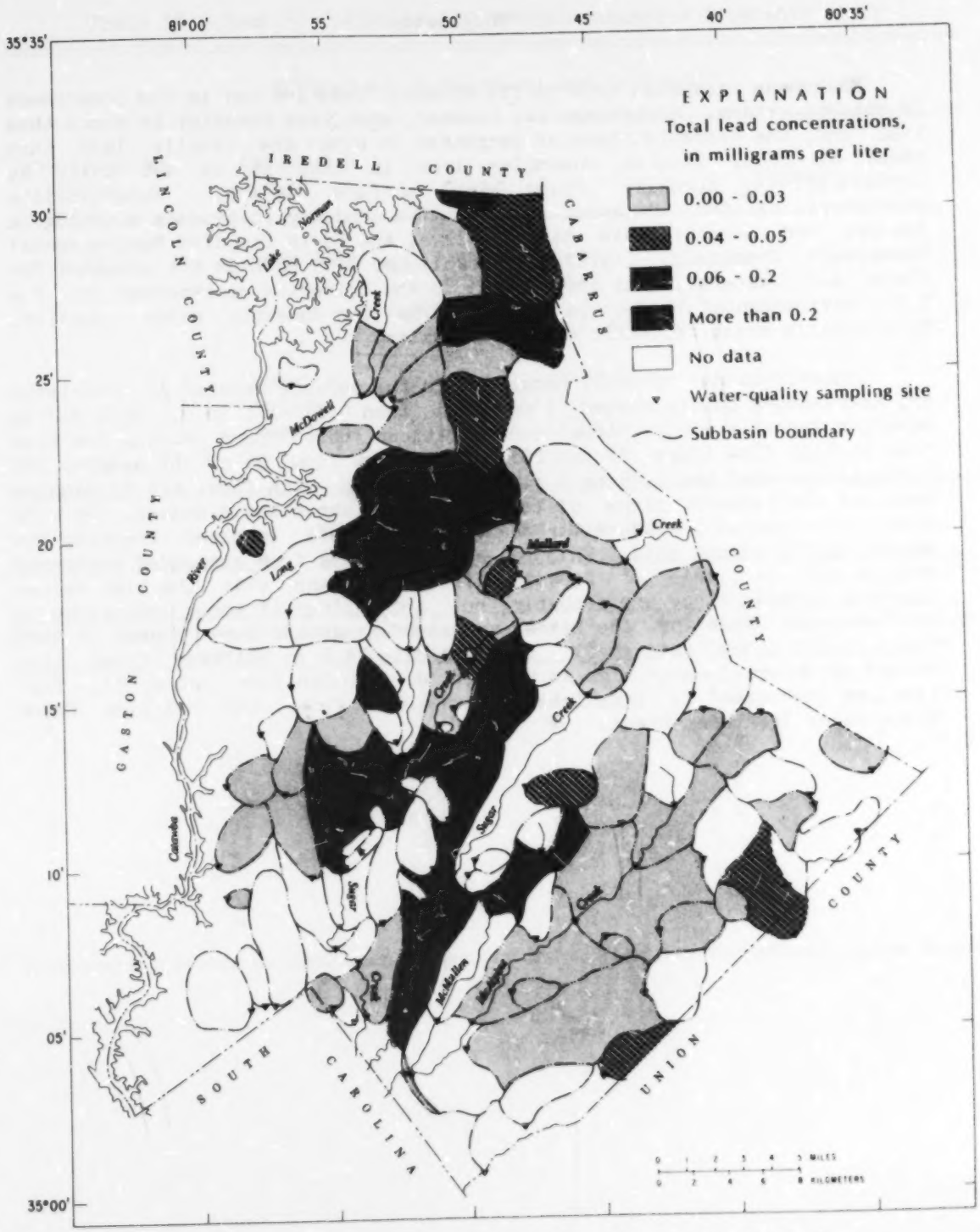



Figure 27.--Total lead concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Manganese

Manganese resembles iron in its chemical behavior and in its occurrence in natural waters. Managanese is, however, much less abundant in rocks than iron and, the concentrations of manganese in water are usually less than those of iron. It also resembles iron in that it is not toxic at concentrations normally found in surface waters. Water-quality considerations for manganese reflect its tendency to produce staining in laundry and objectionable tastes. Thus, the North Carolina Environmental Management Commission (1979) has established 0.05 mg/L as the standard for Class A-II waters. This corresponds to the criterion recommended by the U.S. Environmental Protection Agency (1976a) for domestic water supplies. No standards exist for other classes of water.

Concentrations of total manganese in the surface waters of Charlotte and Mecklenburg County ranged from less than 0.01 mg/L to 6.5 mg/L during sampling for this study. Lower concentrations were found during low flow than at high flow (figs. 28 and 29). During low flow, 96 of 107 samples (90 percent) exceeded the 0.05 mg/L standard. During high flow, all 72 samples measured had concentrations of total manganese above the standard. As with iron, the chemical procedure for measuring manganese involved treating the sample with a strong acid. This releases manganese from suppended sediments that is not available to aquatic life and means that the high values observed in this study are probably not indicative of toxic conditions in the stream. Most of the higher values of manganese were found in the Sugar-Irwin Creek watershed. Sampling site 74.5 on McAlpine Creek also showed concentrations as high as 4.6 mg/L during high flow (table 18). This sampling location is immediately downstream from the McAlpine Creek Waste-Water Treatment Plant.

Table 18.--Summary information for total manganese from this study

Water-Quality Standards and Criteria

| Concentration limits (mg/L) | Applicable to | Authority | Comments |
|---|---|---|---|
| 0.05 | Class A-II | North Carolina Environmental Management Commission (1979). | |
| | Domestic water supplies. | U.S. Environmental Protection Agency (1976a). | |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L) | Sampling site | Rank | Concentration (mg/L) | Sampling site |
| 1 | 1.6 | 2 | 1 | 6.5 | 14 |
| 2 | 1.1 | 9.5 | 2 | 6.2 | 12 |
| 3 | 1.0 | 11 | 3 | 4.6 | 74.5 |
| 4 | .85 | 51 | 4 | 4.5 | 21 |
| 5 | .83 | 86 | 4 | 4.5 | 11 |
| 5 | .83 | 83.5 | 6 | 4.4 | 35 |
| 7 | .81 | 9 | 7 | 3.6 | 41 |
| 8 | .61 | 42 | 8 | 2.9 | 17 |
| 9 | .51 | 5 | 9 | 2.7 | 76 |
| 10 | .46 | 60 | 10 | 1.7 | 3 |

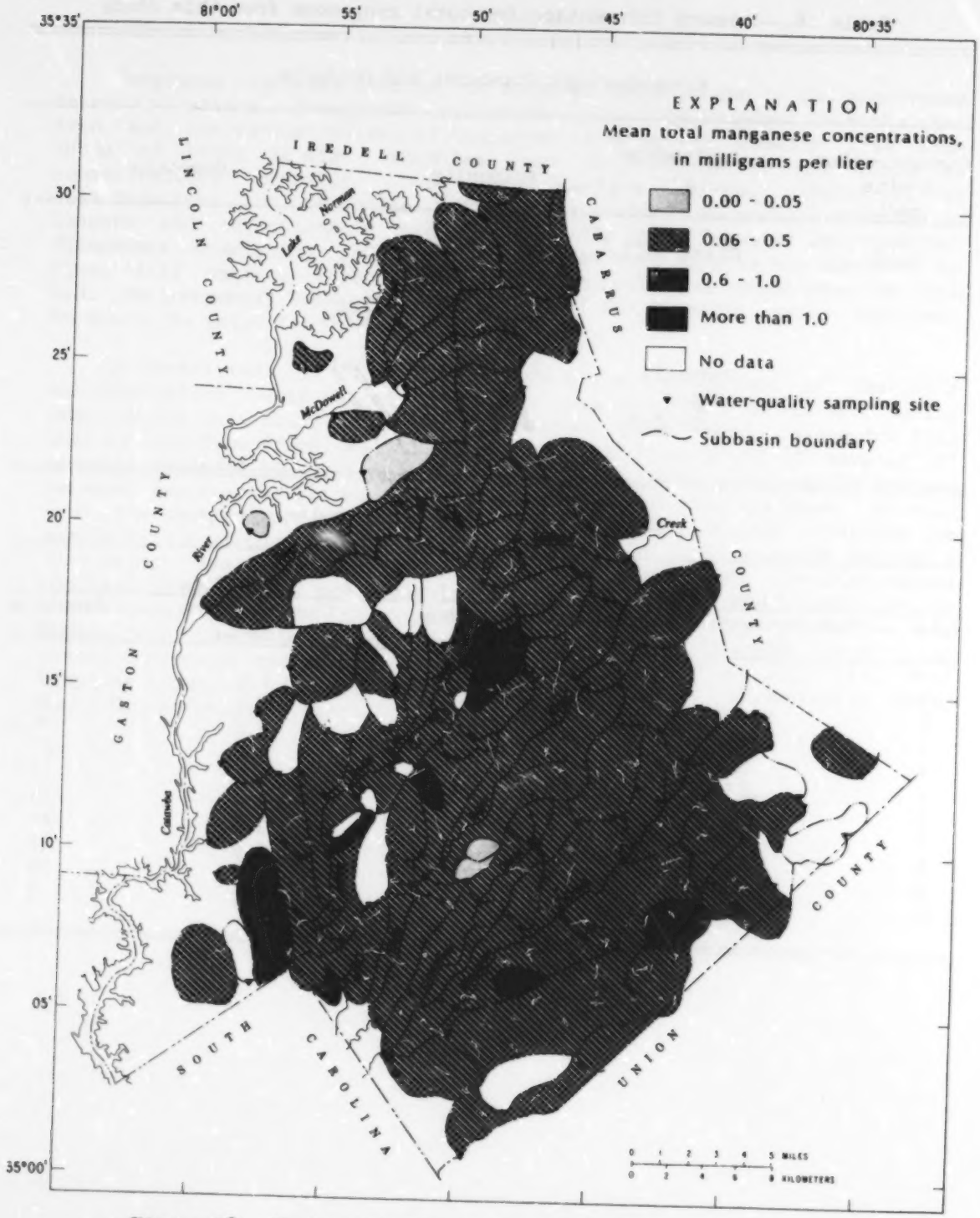



Figure 28.--Mean total manganese concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

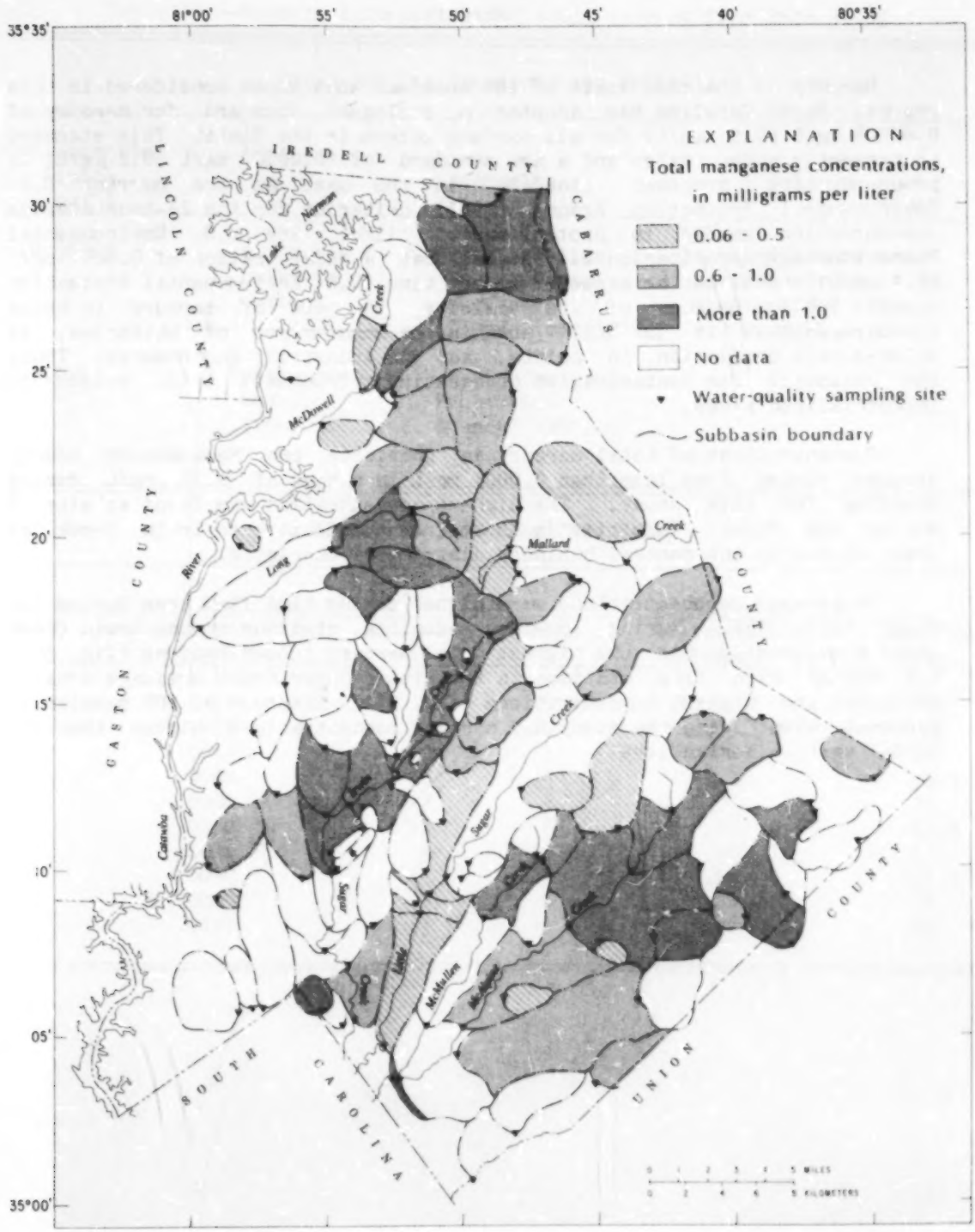



Figure 29.--Total manganese concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Mercury

Mercury is the most toxic of the chemical substances considered in this report. North Carolina has adopted a stringent standard for mercury of 0.00005 mg/L (0.05 µg/L) for all surface waters in the State. This standard is presently under review and a new standard of 0.0002 mg/L (0.2 µg/L) is proposed. The proposed standard is the same as the current U.S. Environmental Protection Agency (1981) criterion for the 24-hour average concentration needed to protect aquatic life. The U.S. Environmental Protection Agency criterion also states that a concentration of 0.0041 mg/L (4.1 µg/L) should not be exceeded at any time (U.S. Environmental Protection Agency, 1981). Because of its toxicity, the use of mercury is being discouraged but it is still used in the manufacture of batteries, in chlor-alkali production, in paints, and in industrial instruments. Thus, the potential for contamination of aquatic environments still exists in industrialized areas.

Concentrations of total mercury in Charlotte and Mecklenburg County streams ranged from less than 0.0001 mg/L to a high of 0.17 mg/L during sampling for this study. The highest concentration was found at site 5 during low flow. This site is located on a tributary to Irwin Creek at Irwin Avenue in the central business district of Charlotte.

In general, concentrations were higher during high flow than during low flow (table 19). During low-flow sampling, stations in the Irwin Creek basin consistently had the highest total mercury concentrations (fig. 30), but during high flow, stations in the Little Sugar Creek drainage usually exhibited the highest concentrations (fig. 31). Nineteen of 205 samples (9 percent) taken during the study had mercury concentrations higher than the 0.0041 mg/L criterion level.

Table 19.--Summary information for total mercury from this study

Water-Quality Standards and Criteria

| Concentration limits (mg/L) | Applicable to | Authority | Comments |
|---|---|---|---|
| 0.00005 | All fresh surface waters. | North Carolina Environmental Management Commission (1979). | Standard is now under review. Probable new standard for 1985 is 0.0002 mg/L. |
| 0.0041 | Freshwater aquatic life. | U.S. Environmental Protection Agency (1981). | |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L) | Sampling site | Rank | Concentration (mg/L) | Sampling site |
| 1 | 0.043 | 5 | 1 | 0.110 | 74.5 |
| 2 | .0050 | 52.5 | 2 | .032 | 110 |
| 3 | .0049 | 9 | 3 | .023 | 55 |
| 4 | .0042 | 2 | 4 | .020 | 56.5 |
| 5 | .0036 | 12 | 5 | .019 | 76 |
| 6 | .0030 | 18 | 5 | .017 | 52.5 |
| 6 | .0030 | 8 | 7 | .012 | 91 |
| 6 | .0030 | 11 | 8 | .010 | 132.5 |
| 9 | .0025 | 16 | 9 | .0088 | 75 |
| 10 | .0021 | 3 | 10 | .0070 | 60 |

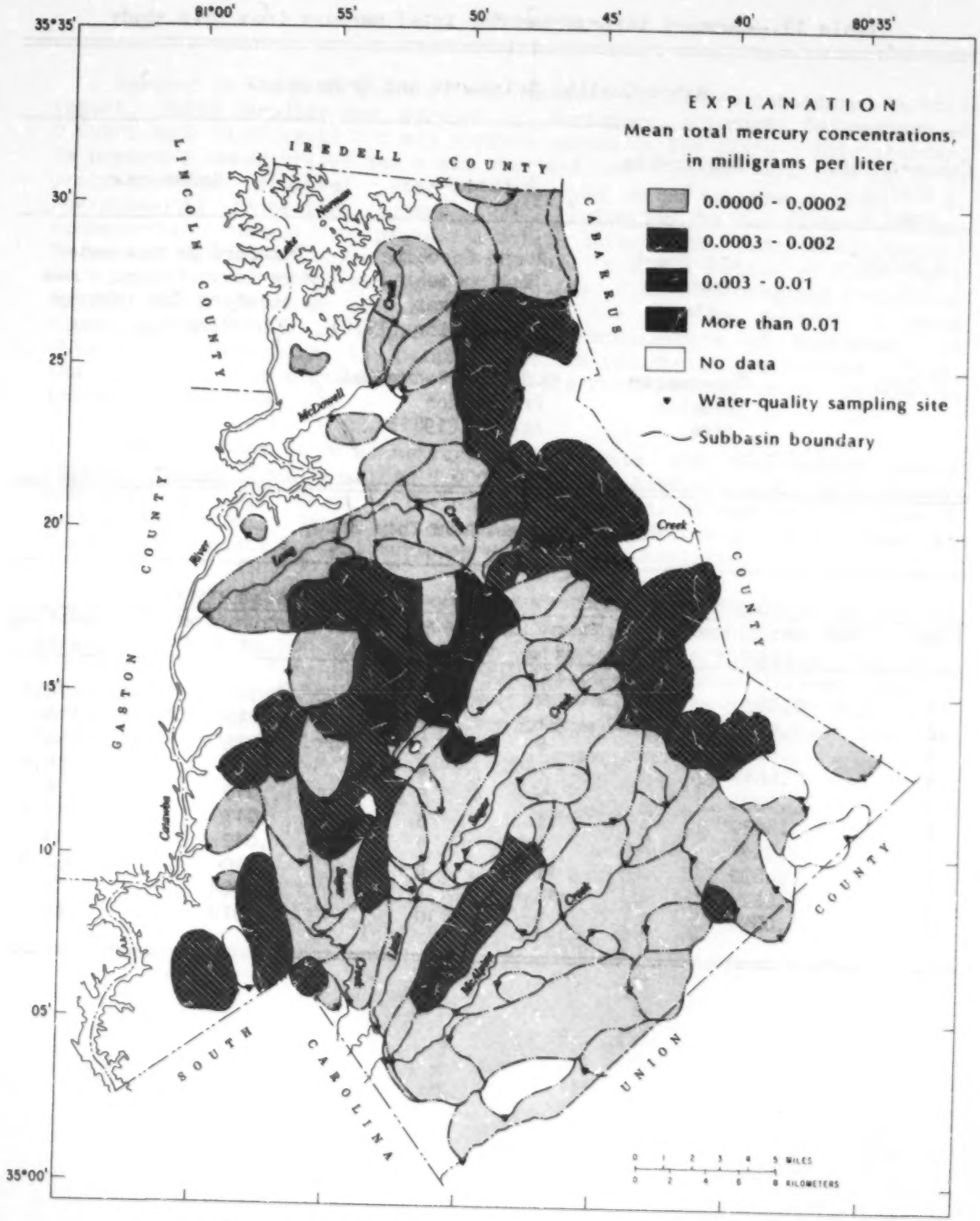



Figure 30.--Mean total mercury concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

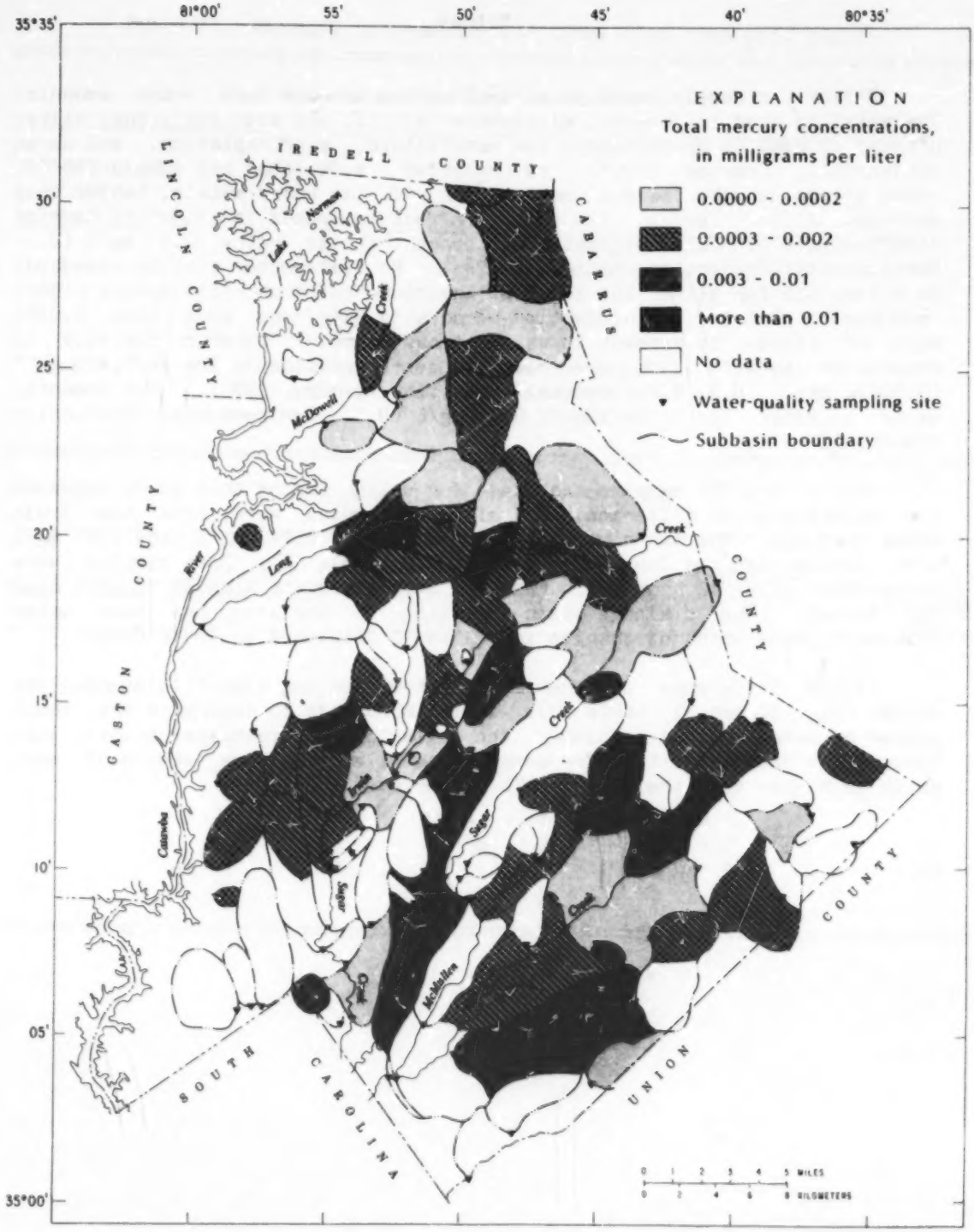



Figure 31.--Total mercury concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Silver

Silver is rarely found in natural waters in more than trace amounts. The metal is used in jewelry, silverware, alloys, and electroplating; silver nitrate is used in photography, ink manufacture, electroplating, and as an antiseptic. Freeman (1977), as reported in Callahan and others (1979), ranks silver as the second most toxic of the heavy metals, behind only mercury. At low levels, its primary effect on humans is cosmetic, causing discoloration of skin pigments at concentrations below 0.5 mg/L (U.S. Environmental Protection Agency, 1976a). No State water-quality standards have been set for silver but the U.S. Environmental Protection Agency (1980) recommended that for the protection of aquatic life, no more than 0.0041 mg/L of silver be present in water at any time. "Chronic toxicity to freshwater aquatic life may occur at concentrations as low as 0.12 µg/L" (0.00012 mg/L) (U.S. Environmental Protection Agency, 1980). For domestic water supplies, the criterion is 0.05 mg/L (U.S. Environmental Protection Agency, 1976a).

Four of the 187 samples analyzed for silver during this study exceeded the drinking water criterion. All of these samples were from the Irwin Creek drainage. The two highest values measured, 0.14 mg/L and 0.47 mg/L were during high and low flow, respectively (table 20). Both samples were taken from site 12, on Irwin Creek at the Interstate Highway 77 exit near 5th Street. The drainage basin for site 12 includes the Vest water treatment plant which discharges into a small tributary to Irwin Creek.

Little difference was seen between low-flow and high-flow samples for silver (fig. 32 and 33, table 20). It is impossible to determine the total number of samples that exceeded the criterion for freshwater aquatic life because the detection limit for some of the silver analyses was 0.02 mg/L which is higher than the 0.0041 mg/L criterion.

Table 21.--Summary information for total zinc from this study

Water-Quality Standards and Criteria

| Concentration limits (mg/L) | Applicable to | Authority | Comments |
|---|---|---|---|
| 5.0 | Domestic water supplies. | U.S. Environmental Protection Agency (1980). | |
| 0.320 | Freshwater aquatic life. | U.S. Environmental Protection Agency (1980). | |

Highest Values From This Study

| | Low flow | | | High flow | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L) | Sampling site | Rank | Concentration (mg/L) | Sampling site |
| 1 | 2.0 | 5 | 1 | 9.0 | 14 |
| 2 | 1.8 | 12 | 2 | 5.2 | 41 |
| 3 | 0.89 | 11 | 3 | 4.8 | 11 |
| 4 | .72 | 2 | 3 | 4.8 | 21 |
| 5 | .25 | 17 | 5 | 4.5 | 46 |
| 6 | .19 | 41 | 5 | 4.5 | 6 |
| 7 | .16 | 21 | 5 | 4.5 | 3 |
| 8 | .12 | 3 | 8 | 3.8 | 12 |
| 9 | .07 | 46 | 9 | 1.9 | 108 |
| 10 | .05 | 108 | 10 | .80 | 17 |

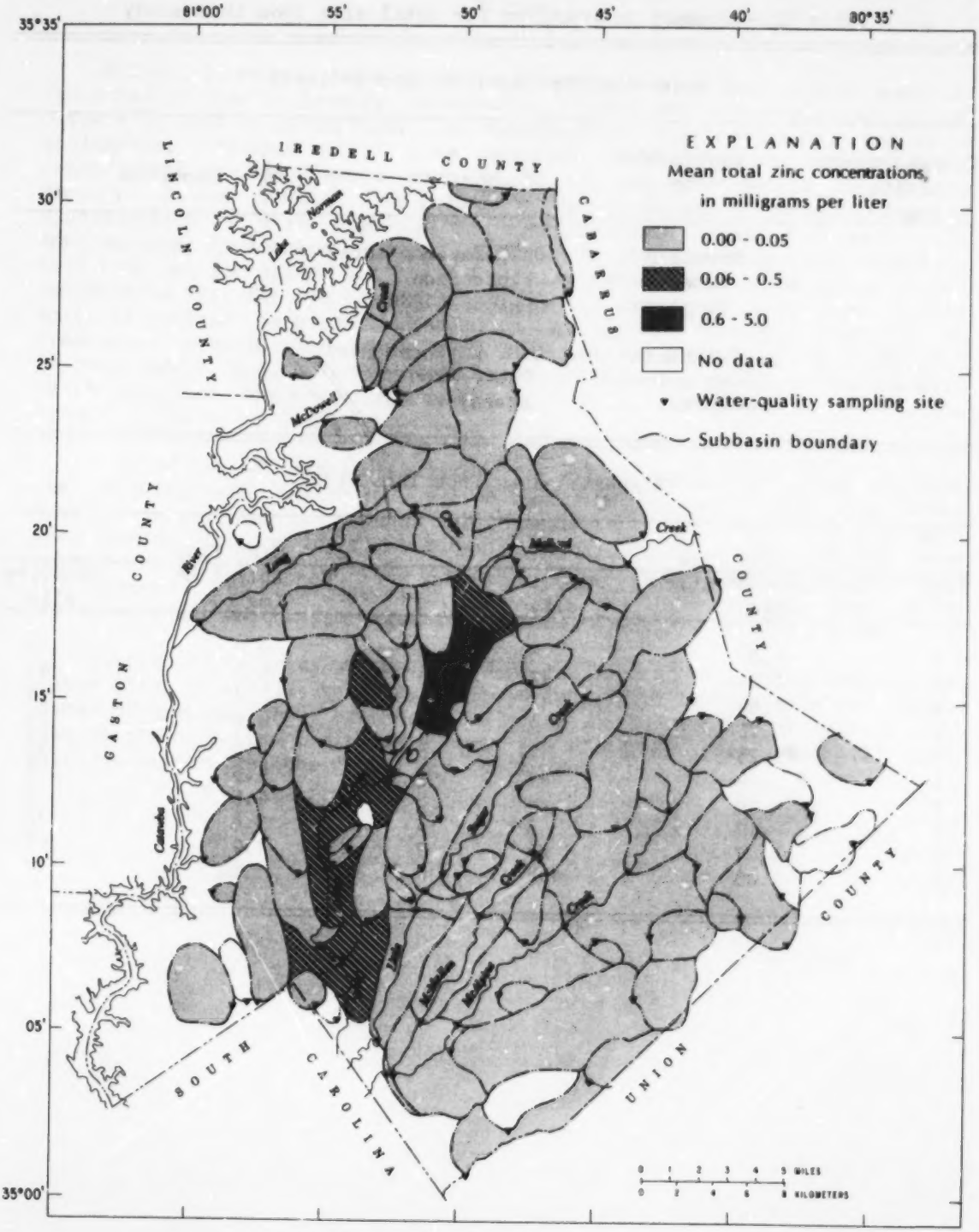



Figure 34.--Mean total zinc concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

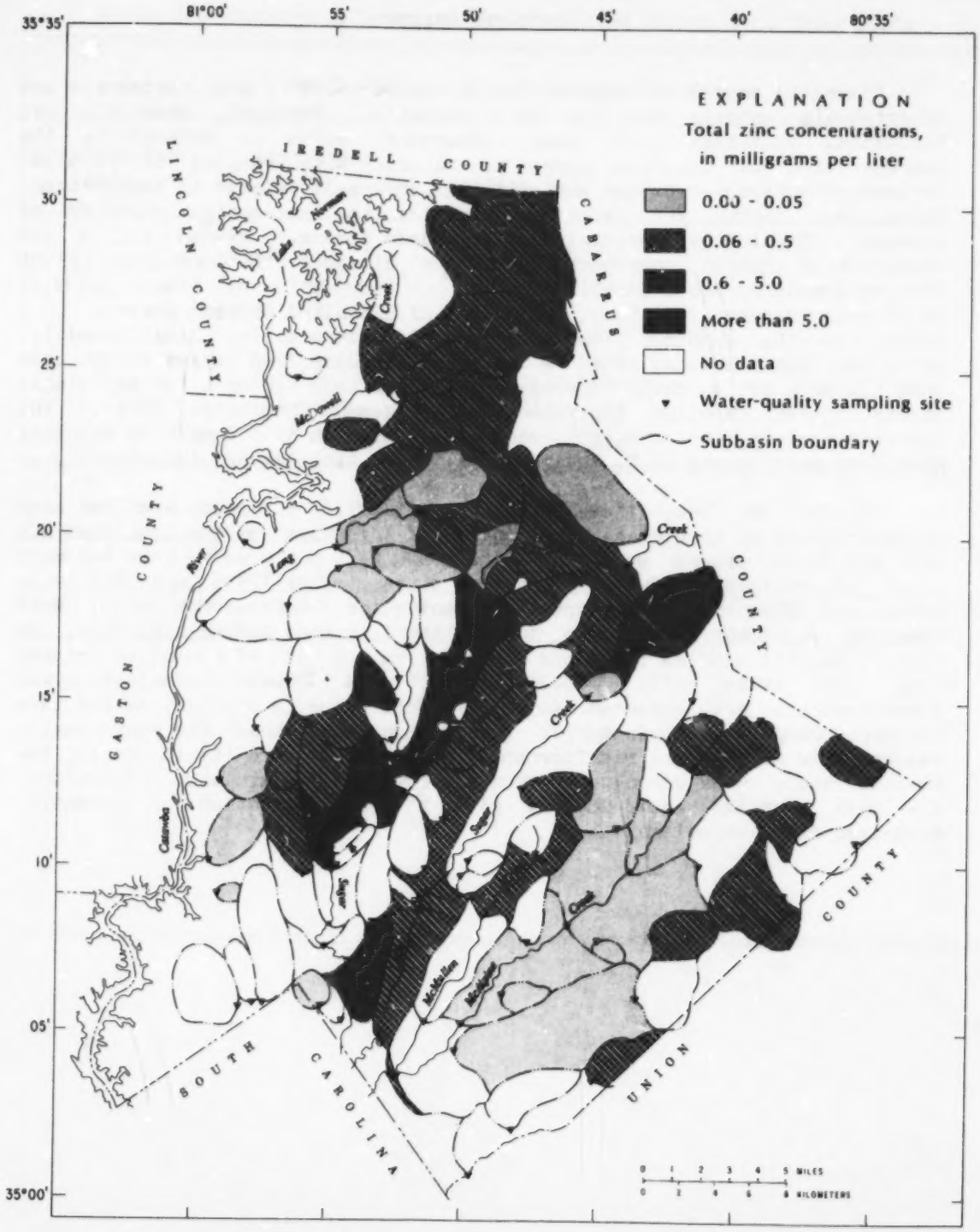



Figure 35.--Total zinc concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Dissolved Oxygen

Dissolved oxygen is required for the respiration of both vertebrate and invertebrate animals and for most bacteria. Physical, chemical, and biological variables all play important roles in determining the concentration of dissolved oxygen in water. With respect to physical variables, dissolved oxygen saturation is inversely related to temperature. Turbulence, depth, and velocity determine the reaeration capacity of streams. Chemically, oxidation of compounds consumes oxygen as in the oxidation of carbon compounds to carbon dioxide. Biologically, plant photosynthesis releases dissolved oxygen but respiration by plants as well as animals consumes it. Thus, the amount of dissolved oxygen present in a stream is the combined result of several factors acting simultaneously. North Carolina has established a standard for dissolved oxygen of not less than 5.0 mg/L as a daily average or not less than 4.0 mg/L for any single sample (North Carolina Environmental Management Commission, 1979). The Environmental Protection Agency recommends a minimum of 5.0 mg/L to maintain good fish populations (U.S. Environmental Protection Agency, 1976a).

During low flow, three sampling sites in the study area had mean concentrations of instantaneous samples of dissolved oxygen less than 4.0 mg/L and three others were less than 5.0 mg/L but greater than 4.0 mg/L (fig. 36, table 22). Two of these six sites (sites 74.5 and 90) were downstream from wastewater treatment facilities. Concentrations at most sampling locations were lower during low flow than during high flow. At high flow, all samples taken had greater than 6.0 mg/L of dissolved oxygen (fig. 37 table 22). Theoretically, the lowest dissolved-oxygen concentrations are expected to occur just prior to daylight during warm weather. Samples for this survey were taken throughout the year usually between late morning and midafternoon. No samples were taken during the predawn hours when dissolved oxygen should be at its minimum. Therefore, the data presented here do not give a true indication of potential dissolved-oxygen problems.

Table 22.--Summary information for dissolved oxygen from this study

Water-Quality Standards and Criteria

| Concentration limits (mg/L) | Applicable to | Authority | Comments |
|---|---|---|---|
| 4.0 | Class A-II, Class B, and Class C. | North Carolina Environmental Management Commission (1979). | |
| 5.0 | Freshwater aquatic life. | U.S. Environmental Protection Agency (1976a). | |

Lowest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L) | Sampling site | Rank | Concentration (mg/L) | Sampling site |
| 1 | 1.7 | 98 | 1 | 6.9 | 35 |
| 2 | 2.5 | 57 | 2 | 7.7 | 71 |
| 3 | 3.8 | 74.5 | 3 | 7.8 | 108 |
| 4 | 4.1 | 86 | 4 | 7.9 | 114 |
| 5 | 4.8 | 90 | 5 | 8.0 | 115.5 |
| 6 | 4.9 | 83 | 5 | 8.0 | 46 |
| 7 | 5.1 | 96 | 5 | 8.0 | 41 |
| 8 | 5.2 | 51 | 8 | 8.2 | 138 |
| 9 | 5.3 | 83.5 | 9 | 8.3 | 112 |
| 10 | 5.4 | 74 | 10 | 8.5 | 110 |

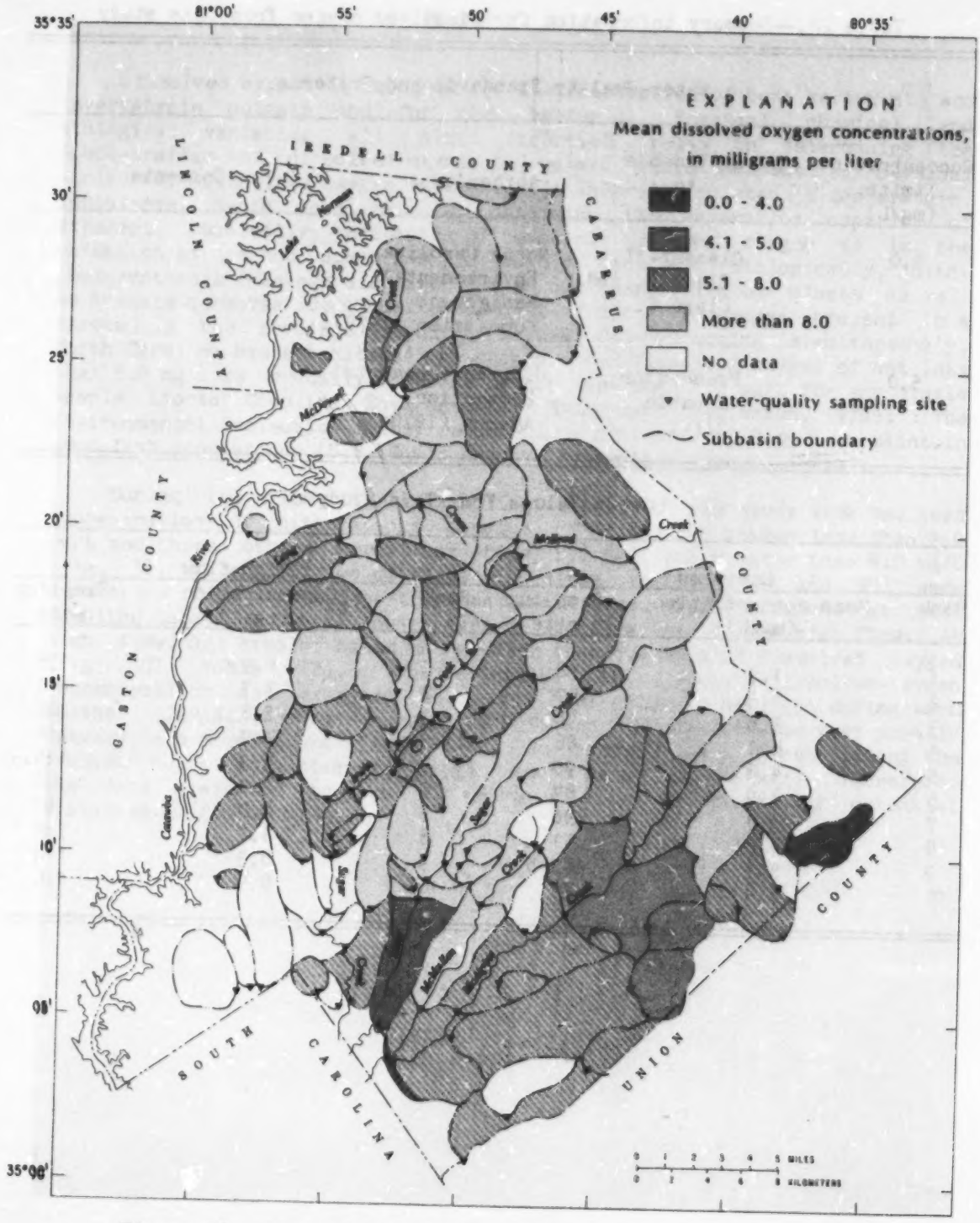



Figure 36.--Mean dissolved oxygen concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

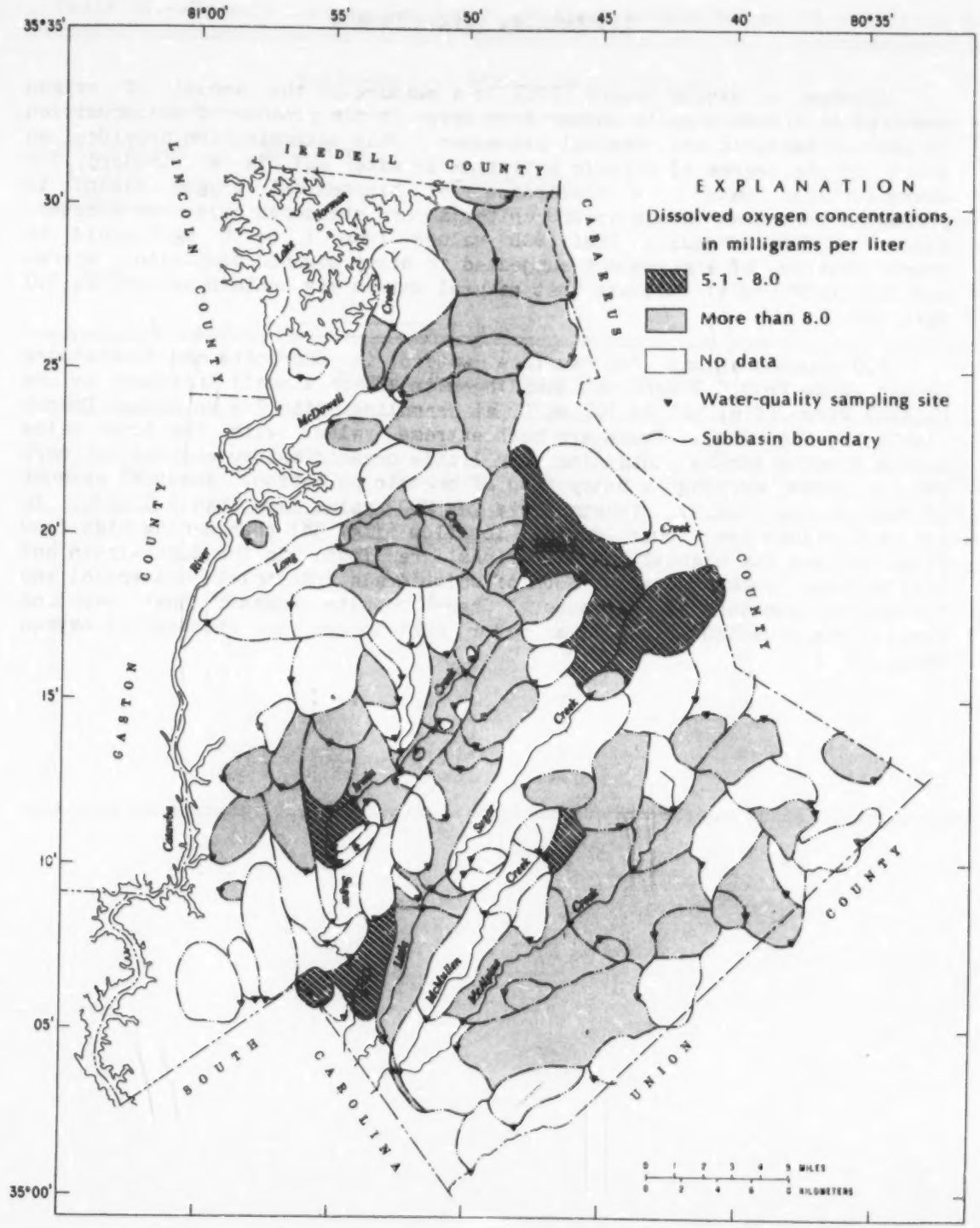



Figure 37.--Dissolved oxygen concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) is a measure of the amount of oxygen required to remove organic matter from water in the process of decomposition by aerobic bacteria and chemical processes. This determination provides an index of the degree of organic pollution in water and is a standard for characterizing water. A discussion of biochemical oxygen demand is presented here even though no BOD criteria or standards have been adopted. Nemerow (1974) suggests that BOD values from 1 to 8 mg/L would be characteristic of streams not subjected to heavy organic pollution. Warren and Doudoroff (1971) indicate that natural waters may contain as much as 5.0 mg/L BOD.

BOD concentrations for surface waters in Charlotte and Mecklenburg County range from 0.3 mg/L at sampling site 135 on a small tributary to the Catawba River (fig. 38) to 107 mg/L at sampling site 134 on Gutter Branch (table 23, fig. 21b). These are both extreme values with the lower value coming from a stream containing very little organic matter and the 107 mg/L fron a stream carying a heavy load of organic pollution. About 77 percent of Mecklenburg County streams have a BOD value less than 8.0 mg/L. In general, values are lower during low flow (fig. 38) than during high flow (fig. 39) and the highest concentrations are found in the Sugar-Irwin and Little Sugar Creek drainages, both of which drain industrial, commercial and residential sections of Charlotte. These results suggest that overland runoff from urbanized areas is a major contributor to biochemical oxygen demand.

Table 23.—Summary information for biochemical oxygen demand from this study

Water-Quality Standards and Criteria

| Concentration limits (mg/L) | Applicable to | Authority | Comments |
|---|---|---|---|
| None | | | |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L) | Sampling site | Rank | Concentration (mg/L) | Sampling site |
| 1 | 17 | 52.5 | 1 | 107 | 134 |
| 2 | 16 | 46 | 2 | 63 | 41 |
| 3 | 14 | 116 | 3 | 44 | 14 |
| 4 | 11 | 41 | 4 | 43 | 21 |
| 5 | 9.6 | 86 | 5 | 36 | 46 |
| 6 | 9.4 | 74 | 5 | 28 | 111 |
| 7 | 9.4 | 90 | 7 | 24 | 132.5 |
| 8 | 8.8 | 11 | 8 | 21 | 71 |
| 9 | 8.5 | 17 | 9 | 20 | 52.5 |
| 10 | 8.1 | 2 | 10 | 19 | 52 |

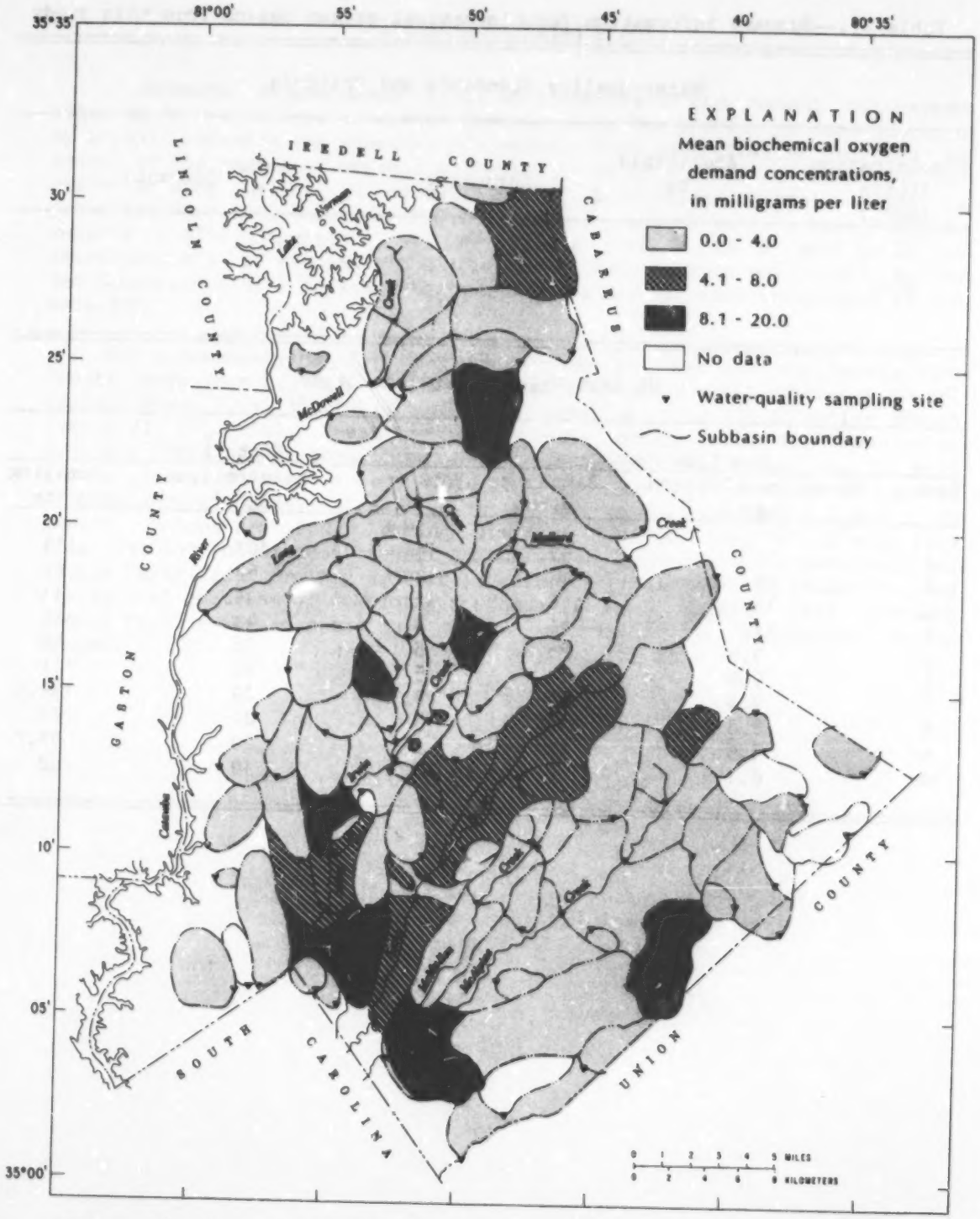



Figure 38.--Mean biochemical oxygen demand concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

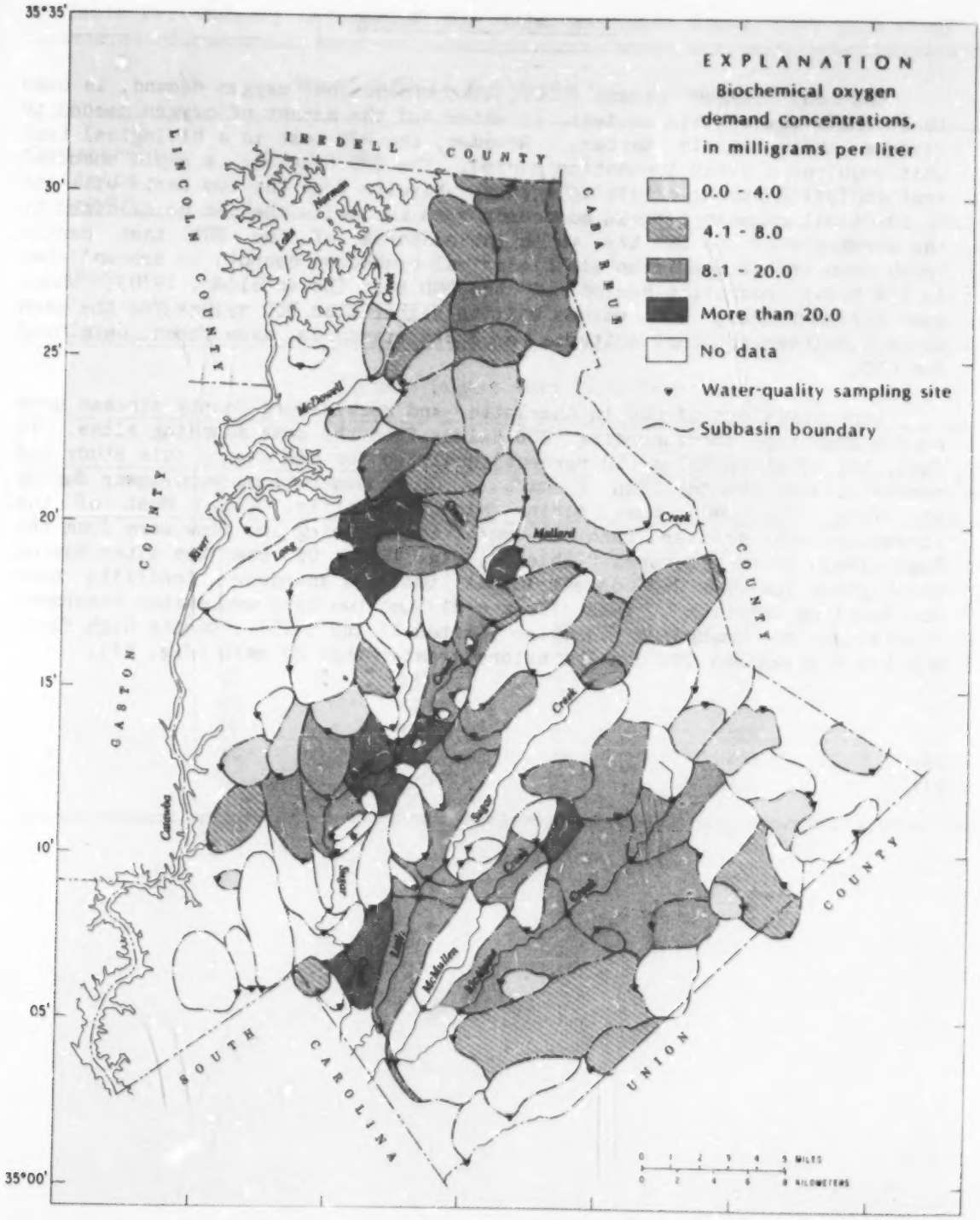



Figure 39.--Biochemical oxygen demand concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Chemical Oxygen Demand

Chemical oxygen demand (COD), like biochemical oxygen demand, is used to estimate the organic content of water and the amount of oxygen needed to oxidize that organic matter. However, the BOD test is a biological test that requires a 5-day incubation period. The COD test is a rapid chemical test employing strong oxidizing agents. Results from the two tests will not be identical because certain compounds such as cellulose can be oxidized by the chemicals of the COD test which the bacteria of the BOD test cannot break down and because complete biological breakdown cannot be accomplished in the 5-day incubation period of the BOD test (Eckenfelder, 1970). Under most circumstances, COD values will be higher than BOD values for the same water. Neither national criteria nor State standards have been developed for COD.

Concentrations of COD in Charlotte and Mecklenburg County streams were much higher than corresponding BOD values from the same sampling sites. In fact, 109 of 210 samples (52 percent) analyzed for COD during this study had concentrations greater than 8 mg/L. COD concentrations were lower during low flow (fig. 40) than during high flow (fig. 41). Most of the concentrations greater than 20 mg/L taken during low flow were from the Sugar-Irwin Creek watershed (table 24, fig. 40). Of the ten sites having the highest low-flow COD concentrations, two have abandoned landfills near the sampling location (sites 12 and 21) and two have wastewater treatment plants near the sampling location (sites 41 and 56.5). During high flow, all but 8 sites had COD concentrations greater than 20 mg/L (fig. 41).

Table 24.--Summary information for chemical oxygen demand from this study

| Water-Quality Standards and Criteria | | | |
|---|---|---|---|
| Concentration limits (mg/L) | Applicable to | Authority | Comments |
| None | | | |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (mg/L) | Sampling site | Rank | Concentration (mg/L) | Sampling site |
| 1 | 96 | 41 | 1 | 460 | 21 |
| 2 | 71 | 5 | 2 | 400 | 14 |
| 3 | 54 | 21 | 3 | 220 | 35 |
| 4 | 51 | 17 | 3 | 220 | 71 |
| 4 | 51 | 12 | 5 | 220 | 119.5 |
| 6 | 48 | 135 | 6 | 200 | 17 |
| 7 | 46 | 124 | 7 | 190 | 41 |
| 8 | 44 | 134 | 8 | 180 | 133 |
| 9 | 34 | 60 | 9 | 160 | 120 |
| 10 | 32 | 56.5 | 10 | 150 | 119 |

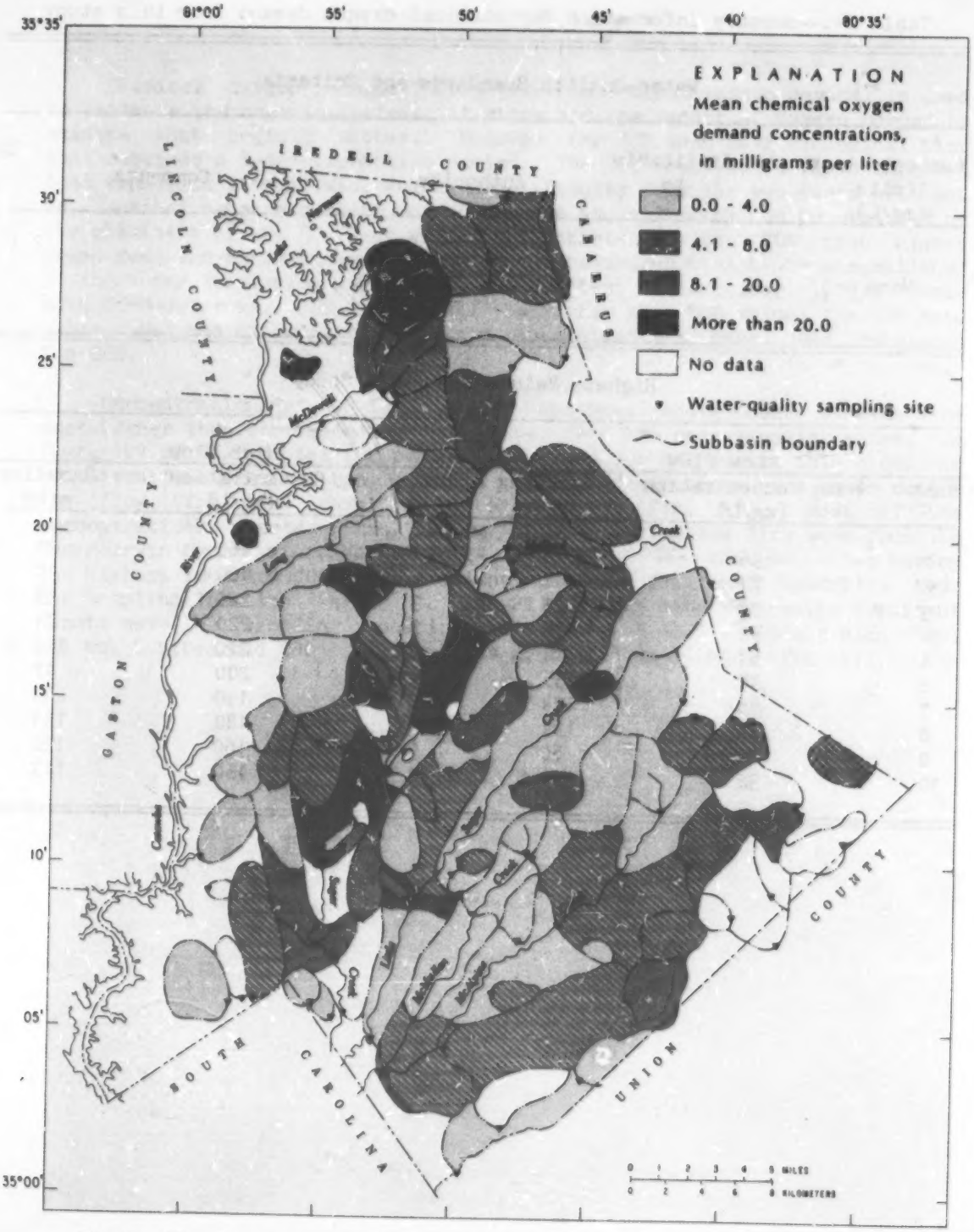



Figure 40.--Mean chemical oxygen demand concentrations during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

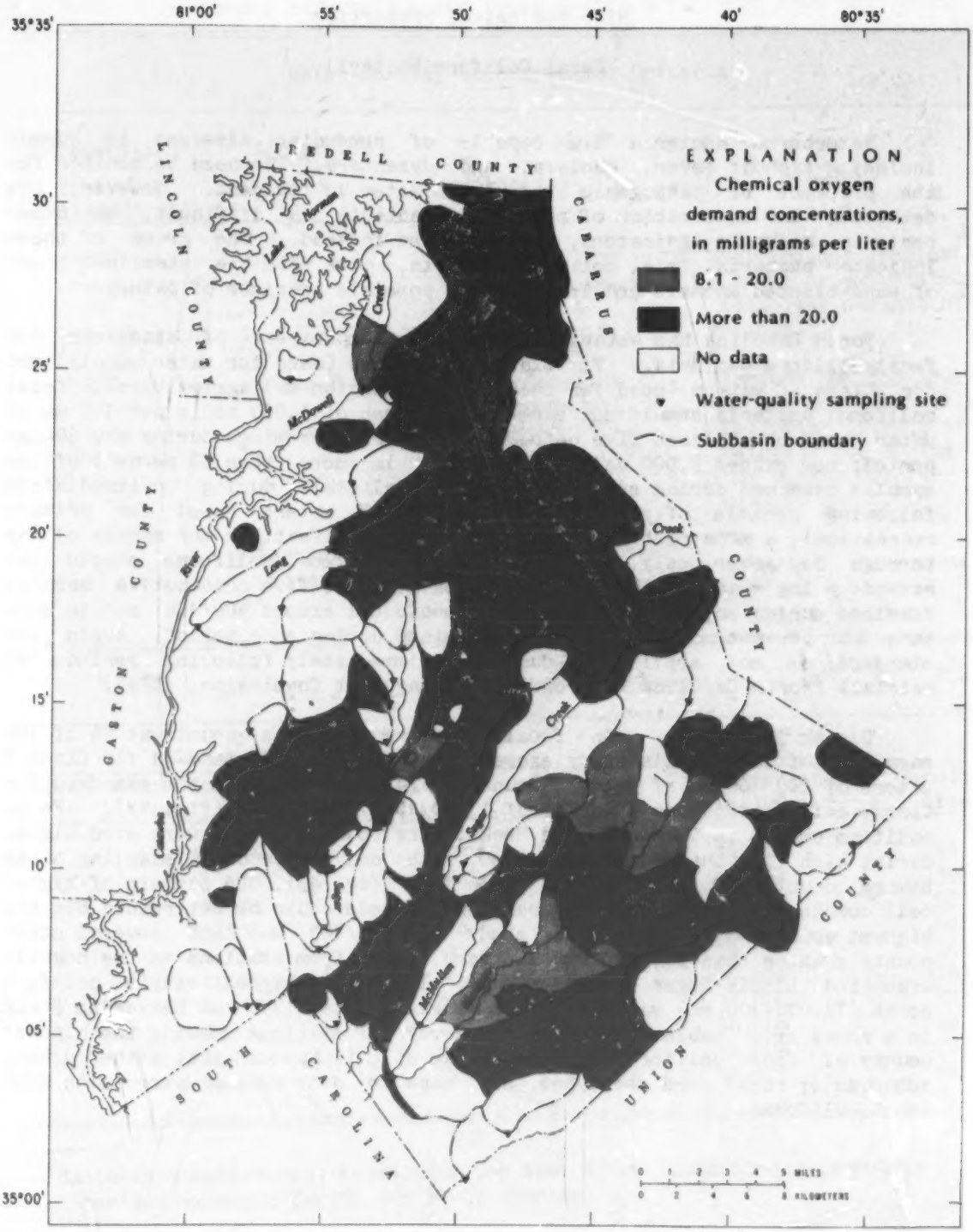



Figure 41.--Chemical oxygen demand concentrations during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Microbiological Properties

### Fecal Coliform Bacteria

Waterborne bacteria are capable of producing diseases in humans including typhoid fever, cholera, and dysentery. The need to monitor for the presence of pathogenic bacteria in water is evident. However, the detection and enumeration of pathogenic bacteria is difficult, so other bacteria, known as indicators, are monitored instead. One group of these indicator bacteria, fecal coliform bacteria, come from the intestinal tract of warm-blooded animals and indicate the possible presence of pathogens.

North Carolina has established a rather complex set of standards for fecal coliform bacteria. For Class A-II waters (used for water supply) and for Class C waters (used for secondary recreation and agriculture), fecal coliform bacteria should not exceed a log mean of 1,000 cells per 100 mL of water based on at least five consecutive samples examined during any 30-day period; nor exceed 2,000 cells per 100 mL in more than 20 percent of the samples examined during such period (not applicable during or immediately following periods of rainfall). For Class B waters (used for primary recreation), a more restrictive standard is in effect for the months of May through September only. The standard is that fecal coliforms should not exceed a log mean of 200/100 mL based on at least five consecutive samples examined during any 30-day period and should not exceed 400/100 mL in more than 20 percent of the samples examined during such period. Again the standard is not applicable during or immediately following periods of rainfall (North Carolina Environmental Management Commission, 1979).

During low flow, mean fecal coliform bacteria counts at 95 of 104 sampling sites in this study exceeded the established standard for Class B waters of 200/100 mL of water. Counts at 71 sites exceeded the standard for Class A-II and Class C waters of 1,000/100 mL of water (fig. 42). Fecal coliform counts in Charlotte and Mecklenburg County streams were even higher during high flow than during low flow, with only three of 68 sampling sites having counts of 1,000/per 100 mL or less (fig. 43). No pattern of higher cell counts in urban versus rural watersheds could be determined but the highest count found during the study (86,000/100 mL) and several other counts greater than 30,000/100 mL were taken from stations in the heavily urbanized Little Sugar Creek drainage. The second highest single coliform count (77,000/100 mL) was taken from sampling site 139, on Beaverdam Creek in a rural area (table 25). From the array of stations showing the highest counts of fecal coliform bacteria (table 25), it appears that either urban, suburban or rural land use types are capable of yielding waters with high fecal coliforms.

Table 25.--Summary information for fecal coliform bacteria from this study

Water-Quality Standards and Criteria

| Concentration limits[1/] (cells/100 mL) | Applicable to | Authority | Comments |
|---|---|---|---|
| 1000 | Class A-II | North Carolina Environmental Management Commission (1979). | Standard not applicable during or immediately following periods of rainfall. |
| 200 | Class B | North Carolina Environmental Management Commission (1979). | Standard not applicable during or immediately following peirods of rainfall nor during the months October through April. |
| | Bathing waters. | U.S. Environmental Protection Agency (1976a). | |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (cells/100 mL) | Sampling site | Rank | Concentration (cells/100 mL) | Sampling site |
| 1 | 20,000 | 60 | 1 | 86,000 | 51 |
| 1 | 20,000 | 52.5 | 2 | 77,000 | 139 |
| 3 | 18,200 | 52 | 3 | 72,000 | 52.5 |
| 4 | 17,600 | 116 | 4 | 66,000 | 52 |
| 5 | 14,600 | 83.5 | 5 | 44,000 | 35 |
| 5 | 14,600 | 133 | 6 | 38,000 | 118 |
| 7 | 10,000 | 50 | 7 | 37,000 | 57 |
| 7 | 10,000 | 5 | 8 | 35,600 | 140 |
| 9 | 9,400 | 131 | 9 | 34,000 | 120 |
| 10 | 8,600 | 132.5 | 9 | 34,000 | 56.5 |

[1/] Bacteria standards are based on a log mean of at least five consecutive samples examined during any 30-day period.



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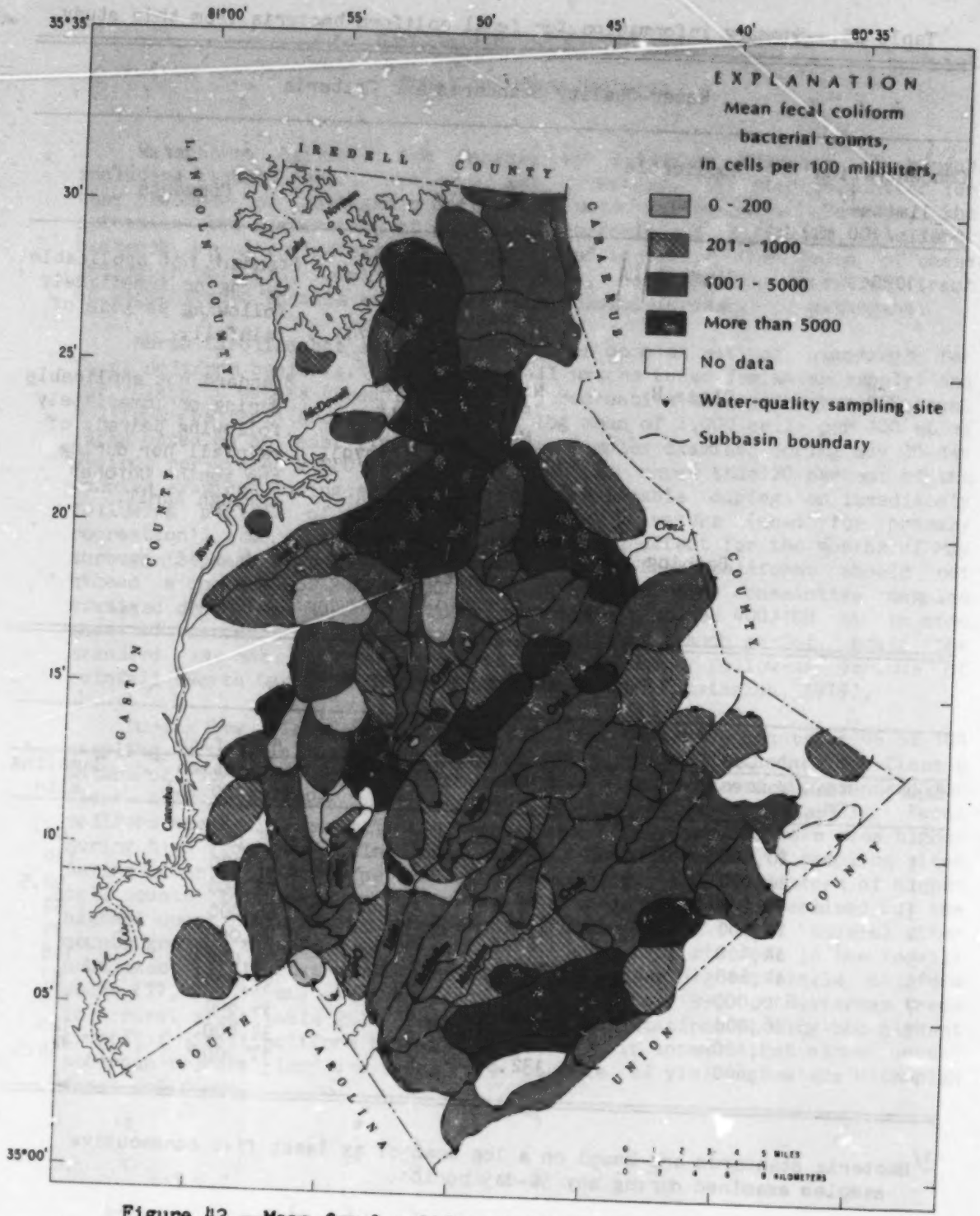


Figure 42.--Mean fecal coliform bacteria counts during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

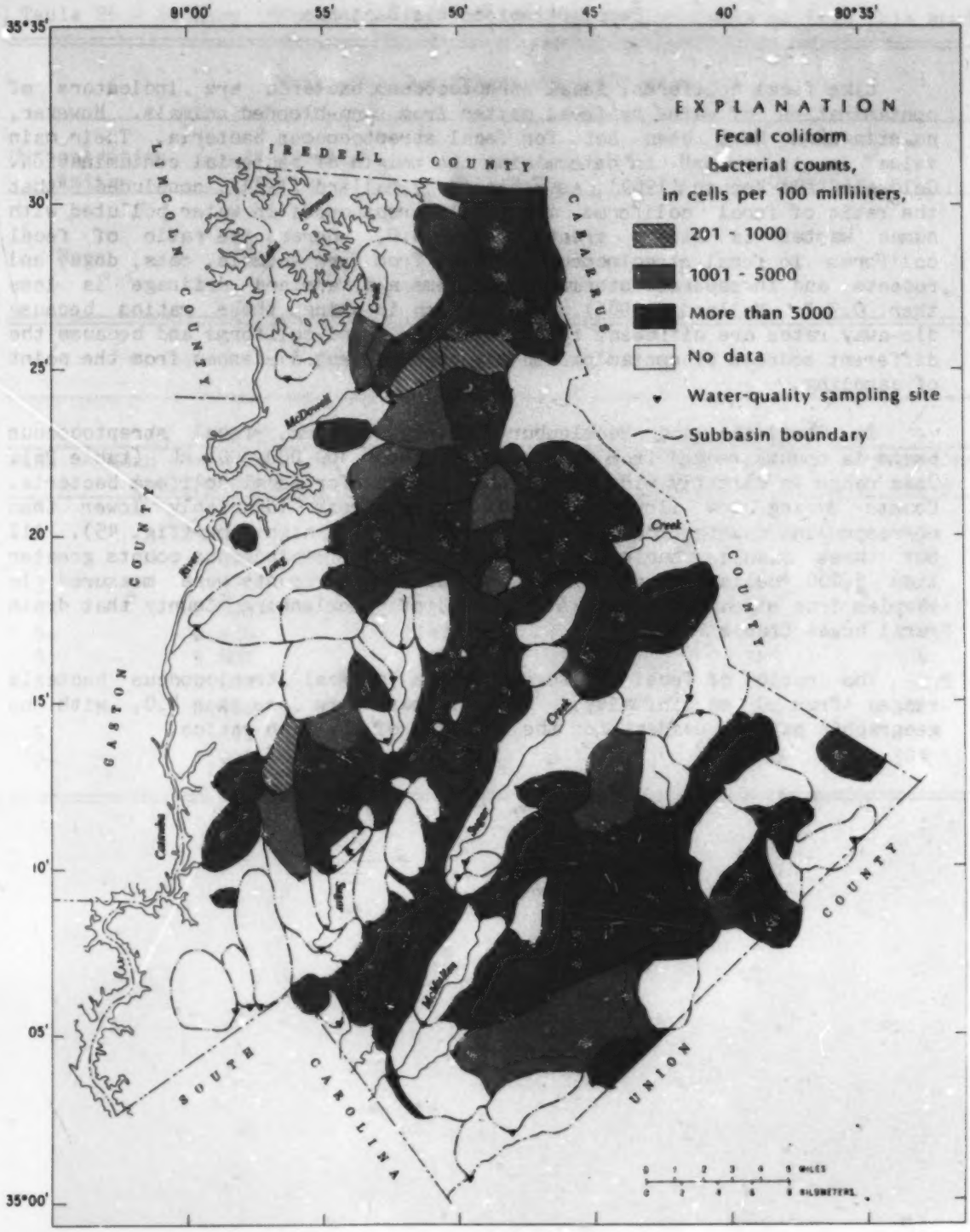


Figure 43.--Fecal coliform bacteria counts during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## Fecal Streptococcus Bacteria

Like fecal coliforms, fecal streptococcus bacteria are indicators of contamination of water by fecal matter from warm-blooded animals. However, no standards have been set for fecal streptococcus bacteria. Their main value is to assist in determining the origin of bacterial contamination. Geldreich and Kenner (1969), as reported by Mallard (1981), concluded "that the ratio of fecal coliforms to fecal streptococci in water polluted with human wastes is always greater than 4.0, whereas the ratio of fecal coliforms to fecal streptococci in feces from farm animals, cats, dogs, and rodents and in separate stormwater systems and farmland drainage is less than 0.7." Mallard (1981) urges caution in using these ratios because die-away rates are different for streptococci and coliforms and because the different sources of contamination may be different distances from the point of sampling.

In Charlotte and Mecklenburg County streams, fecal streptococcus bacteria counts ranged from 0 to greater than 100,000/100 mL (table 26). This range is slightly wider than the counts for fecal coliform bacteria. Counts during low flow (fig. 44) were almost invariably lower than corresponding counts from the same stations during high flow (fig. 45). All but three samples during high flow had fecal streptococcus counts greater than 5,000 cells/100 mL. Many of the highest counts were measured in samples from streams in the eastern part of Mecklenburg County that drain rural areas (table 26).

The ratio of fecal coliform bacteria to fecal streptococcus bacteria ranged from 0 to infinity. Most values were less than 4.0, with no geographic pattern evident for the location of the high ratios.

Table 26.--Summary information for fecal streptococcus bacteria from this study

Water-Quality Standards and Criteria

| Concentration limits | Applicable to | Authority | Comments |
|---|---|---|---|
| None | | | |

Highest Values From This Study

| Low flow | | | High flow | | |
|---|---|---|---|---|---|
| Rank | Mean concentration (cells/100 mL) | Sampling site | Rank | Concentration (cells/100 mL) | Sampling site |
| 1 | 24,550 | 5 | 1 | >100,000 | 35 |
| 2 | 4,900 | 6 | 1 | >100,000 | 40 |
| 3 | 4,800 | 126 | 3 | 98,000 | 114 |
| 4 | 2,800 | 138 | 4 | 97,000 | 118 |
| 5 | 2,700 | 140 | 5 | 95,000 | 115.5 |
| 6 | 2,600 | 128 | 6 | 93,000 | 108 |
| 6 | 2,600 | 139 | 7 | 90,000 | 52.5 |
| 6 | 2,600 | 15 | 8 | 88,000 | 52 |
| 9 | 2,200 | 133 | 9 | 86,000 | 51 |
| 10 | 1,900 | 117 | 10 | 76,000 | 101 |

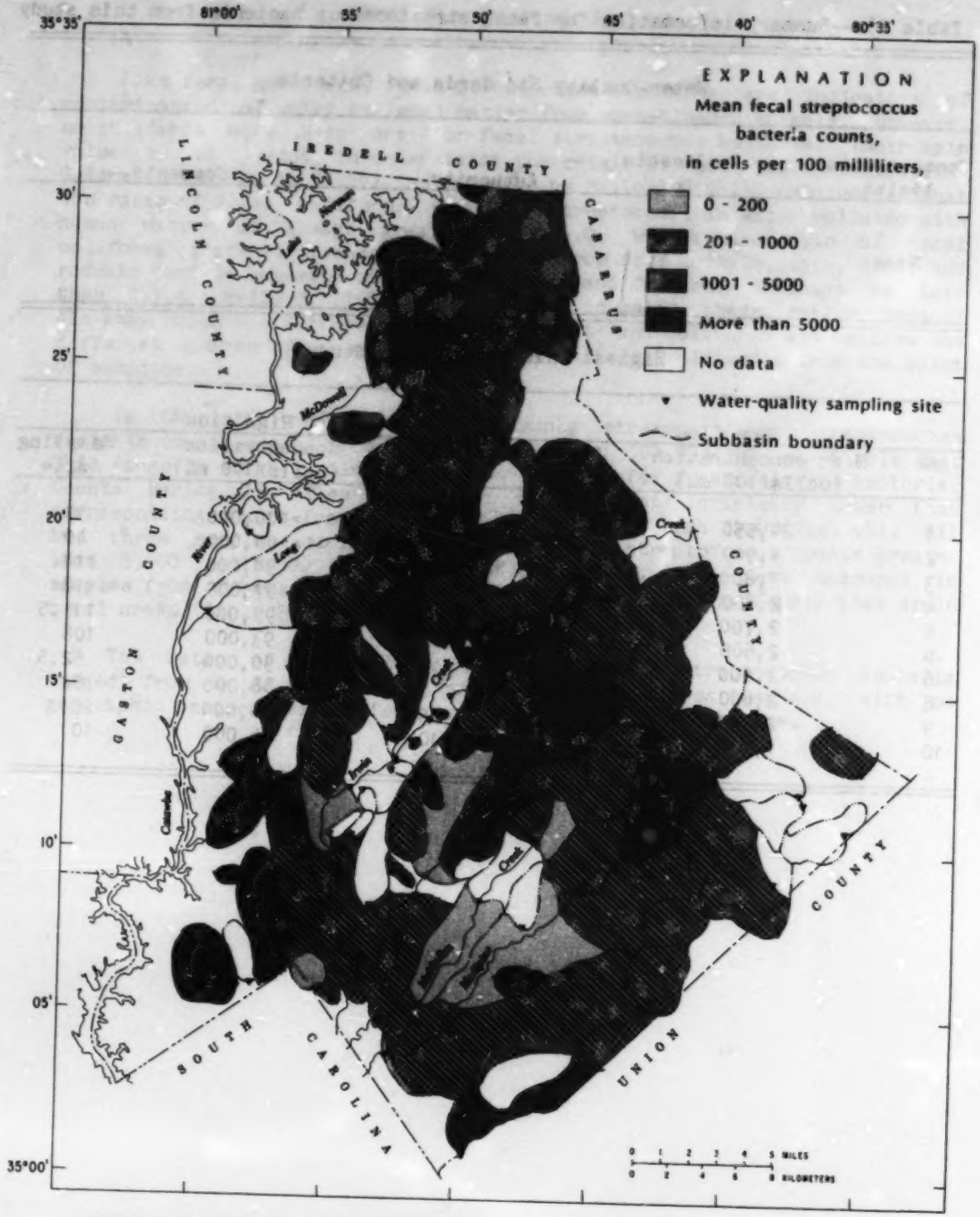


Figure 44.--Mean fecal stretpococcus bacteria counts during low flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

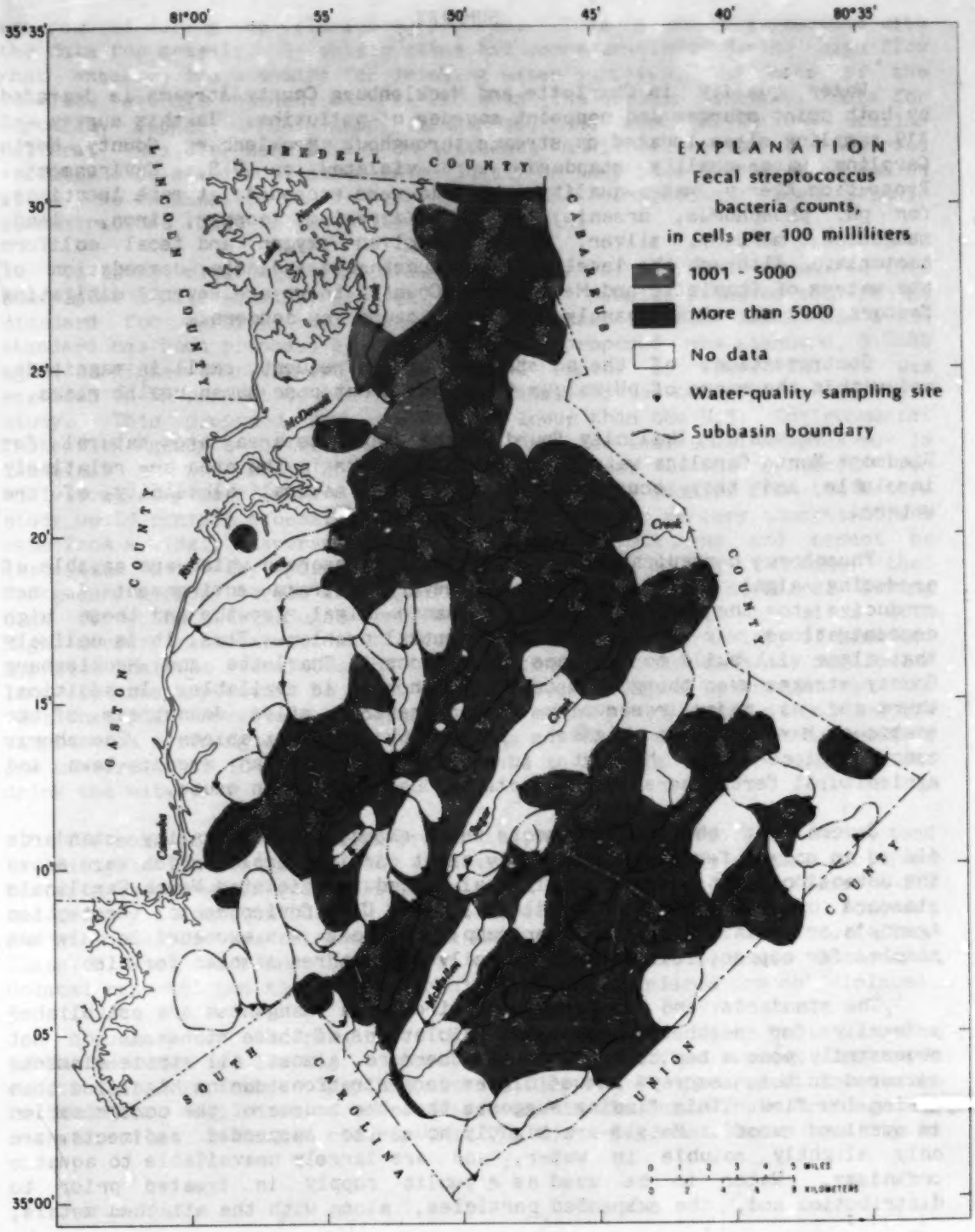


Figure 45.—Fecal streptococcus bacteria counts during high flow in streams in the City of Charlotte and Mecklenburg County, North Carolina

## SUMMARY

Water quality in Charlotte and Mecklenburg County streams is degraded by both point sources and nonpoint sources of pollution. In this survey of 119 sampling sites located on streams throughout Mecklenburg County, North Carolina water-quality standards were violated or U.S. Environmental Protection Agency water-quality criteria were exceeded, at some locations, for pH, phosphorus, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, silver, zinc, dissolved oxygen, and fecal coliform bacteria. Although the levels of many substances indicate degredation of the waters of Charlotte and Mecklenburg County, there are several mitigating factors that may significantly reduce the cause for concern.

Contraventions of the pH standard are infrequent, small in magnitude, and within the range of pH values that should not pose human health risks.

Low values of alkalinity found in the Charlotte area are natural for Piedmont North Carolina waters. Underlying rocks in the area are relatively insoluble and they contribute little to the natural alkalinity of the waters.

Phosphorus concentrations were frequently observed which are capable of producing algal blooms in lakes. However, a stream environment is not conducive to the production of nuisance algal growths and these high concentrations may not represent a potential problem. Thus, it is unlikely that algae will build to nuisance populations in Charlotte and Mecklenburg County streams even though abundant phosphorus is available. In addition, there are no major reservoirs within several miles downstream of the stations having the highest phosphorus concentrations. Phosphorus concentrations are highest in rural and suburban areas; lawn and agricultural fertilizers are suspected as being the main cause.

Several of the trace elements which exceeded water-quality standards did so in only a few instances. Only eight cadmium samples which were above the detection limits of the analytical procedures violated North Carolina's standard of 0.004 mg/L. Similarly, the U.S. Environmental Protection Agency's criteria for public water-supply sources was exceeded in only two samples for copper, four samples for silver and three samples for zinc.

The standards and criteria for iron and manganese are established primarily for aesthetic purposes. Violations of these standards do not necessarily pose a health problem. Furthermore, almost all trace elements measured in this survey showed higher concentrations during high flow than during low flow. This finding suggests that the source of the contamination is overland runoff. Metals are tightly bound to suspended sediments, are only slightly soluble in water, and are largely unavailable to aquatic organisms. Water to be used as a public supply is treated prior to distribution and, the suspended particles, along with the attached metals,

are removed during the filtration process. This point is emphasized with the data for arsenic. Seventeen sites had concentrations during high flow that exceeded the standard for drinking water supplies, but none of the low-flow average concentrations exceeded the arsenic standard. Data for chromium, copper, iron, lead, manganese, and zinc exhibit a similar pattern. Thus, for many of the constituents monitored, either the observed violations of standards occur infrequently or they pose little or no health risks. No explanation can be offered for the consistently high arsenic concentrations found in the Mallard Creek basin.

It is not clear whether the concentrations of mercury found in this study pose a water-quality problem. All the samples exceeded the present standard for mercury, but the present standard is under review and a new standard has been proposed by the State. The proposed new standard, 0.0002 mg/L, is higher than the old standard by a factor of four, and it was exceeded in 52 percent of all the samples analyzed for mercury during this study. This proposed new standard is lower than the U.S. Environmental Protection Agency's criterion of 0.0041 mg/L for individual samples but is identical to the EPA's 24-hour average criterion. If the criterion for individual samples of 0.0041 mg/L is used, only 19 samples from the entire study would contain excessive mercury. The higher mercury concentrations came from a widely dispersed group of sampling stations and cannot be associated with any point-source discharge. This may indicate that background mercury levels are higher than the proposed new standard. During high flow, the Little Sugar Creek basin produced a cluster of sites with high mercury concentrations. These sites include a variety of land-use types so that the association of the high concentrations with any particular land-use category cannot be made. Again, attention must be brought to the fact that the laboratory procedure for mercury involves dissolving the sample with a strong acid. This procedure may cause mercury to be released and measured that is not normally available to aquatic life or to humans who drink the water.

For some of the biological properties, situations also exist which tend to mitigate the severity of standards contraventions. Fecal coliform bacteria exceed water-quality standards for both drinking water (Class A-II) and primary recreation (Class B) in most of the samples analyzed. However, almost none of the streams in the County are classified as Class A-II or Class B (North Carolina Department of Natural and Economic Resources, undated reports) and therefore, technically, the standards are not violated.

A summary of the results of this study is presented in table 27. The table includes a listing of locations where extreme values for each constituent were found. Sampling sites 5, 14, and 41 appear most frequently in this list. All three of these sites are in the Sugar-Irwin drainage and overall, that drainage clearly has the most degraded water quality in

# Table 27.— Standards, violations of standards, extreme concentrations, and locations of extreme concentrations for the constituents considered in this study

[Standards from North Carolina Environmental Management Commission, 1980. Criteria from U.S. Environmental Protection Agency, 1976a, 1980, 1981.]

| Constituent | North Carolina water-quality standards | U.S. EPA water-quality criteria | Percent of samples from this study that exceed standard: Low flow | Percent of samples from this study that exceed standard: High flow | Extreme values found in this study: Low flow | Extreme values found in this study: High flow | Location of extreme values |
|---|---|---|---|---|---|---|---|
| Specific conductance. | None | None | Not applicable. | Not applicable. | 950 uho/cm | 325 uho/cm | Sites 2,11. |
| Dissolved chloride. | do. | [1] 250 mg/L | 0 | 0 | 140.3 mg/L | 38 mg/L | Site 2. |
| Total hardness. | do. | None | Not applicable. | Not applicable. | 350 mg/L | 160 mg/L | Sites 2, 11. |
| pH | [2,3,4] 6.0 - 8.5 | [1] 5.0 - 9.0<br>[5] 6.5 - 9.0 | 17<br>15<br>2 | 13<br>13<br>0 | 5.2-10.9 | 6.0-8.3 | Sites 21, 41. |
| Total alkalinity. | None | [5] 20 mg/L except where naturally less. | 0 | 0 | 295 mg/L | 157 mg/L | Site 6. |
| Total phosphorus. | do. | None | Not applicable. | Not applicable. | 5.0 mg/L | 2.6 mg/L | Sites 21, 41. |
| Total arsenic. | [2] 0.05 mg/L<br>[3,4] 0.10 mg/L | [1] 0.05 mg/L<br>[4] 0.10 mg/L<br>[5] 0.94 mg/L | 8<br>0<br>0 | 28<br>13<br>1 | 0.86 mg/L | 0.475 mg/L | Site 75, Mallard Creek basin. |
| Total cadmium. | 0.004 mg/L | [1] 0.010 mg/L<br>[5] 0.003 mg/L<br>0.01 mg/L | [7] <21<br>[7] <21<br><22 | 8<br>6<br>8 | 0.22 mg/L | 0.008 mg/L | Site 5. |
| Total chromium. | [2] 0.05 mg/L<br>[4] 0.10 mg/L | [1] 0.05 mg/L<br>[5] 0.10 mg/L | 5<br>3 | 43<br>24 | 0.370 mg/L | 0.590 mg/L | Site 14, Sugar-Irwin basin. |
| Total copper. | None | [1] 0.10 mg/L<br>[5] 0.022 mg/L | 2<br>[7] <9 | 31<br>[7] <85 | 2.59 mg/L | 2.35 mg/L | Sites 5, 14. |
| Total iron. | 1.0 mg/L | [1] 0.3 mg/L | 22<br>79 | 99<br>99 | 56.2 mg/L | 824 mg/L | Site 14, Sugar-Irwin basin. |
| Total lead. | 0.03 mg/L | [1] 0.05 mg/L<br>[5] 0.17 mg/L | 5<br>2<br>0 | 43<br>32<br>6 | 0.6 mg/L | 1.34 mg/L | Site 41. |
| Total manganese | [2] 0.05 mg/L | [1] 0.05 mg/L | 90 | 100 | 1.91 mg/L | 6.50 mg/L | Site 14. |
| Total mercury | [8] 0.00005 mg/L<br>[9] 0.0002 mg/L | [5] 0.0041 mg/L | [7] <100<br>[7] < 43<br>6 | [7] <100<br>< 69<br>35 | 0.170 mg/L | 0.114 mg/L | Site 5, Little Sugar basin. |
| Total silver | None | [1] 0.05 mg/L<br>[5] 0.0041 mg/L | [7] 2<br><20 | [7] 3<br><26 | 0.470 mg/L | 0.135 mg/L | Site 12. |
| Total zinc | do. | [5] 5.0 mg/L<br>0.320 mg/L | 1<br>3 | 3<br>19 | 7.81 mg/L | 9.02 mg/L | Sites 14, 5. |
| Dissolved oxygen | 4.0 mg/L | 5.0 mg/L | 6<br>2 | 0<br>0 | 1.7 mg/L | 6.9 mg/L | Sites 98, 57, 74.5. |
| Biochemical oxygen demand | None | None | Not applicable. | Not applicable. | 25.5 mg/L | 107 mg/L | Sites 134, 11, 2 41, 14, 21, 46. |
| Chemical oxygen demand | do. | do. | do. | do. | 166 mg/L | 460 mg/L | Sites 35, 71, 119.5, 5, 21, 41. |
| Fecal coliform bacteria | [2,6] 1,000 cells/ 100 mL | | 61 | do. | 20,000 cells/ 100 mL | 85,000 cells/ 100mL | Sites 60, 52.5, 52, 116, 5. |
| | [3] 200 cells/ 100 mL | [10] 200 cells/ 100 mL | 62 | do. | | | |
| Fecal streptococcus bacteria | None | None | Not applicable. | do. | 49,000 cells/ 100 mL | >100,000 cells/ 100 mL | Sites 35, 60, 5. |

[1] Criterion for domestic water supplies.
[2] Standard for Class A-II waters.
[3] Standard for Class B waters.
[4] Standard for Class C waters.
[5] Criterion for freshwater aquatic life.
[6] Criterion for irrigation of crops.
[7] Detection limit is less than standard.
[8] Standard is now under review
[9] Probable new standard.
[10] Criterion for bathing water.

Mecklenburg County. The Irwin Creek Waste-Water Treatment Plant is less than 2 miles upstream from sampling site 41 but no point-source discharge exists in the subbasin of sampling site 5. Nine effluent discharges are included in the watershed of site 14, but all of these except one (Discovery Place Museum) have at least one other sampling site between the discharge and site 14, and water quality at these other sites was found to be better than at site 14. Thus, it appears that non-point sources in the subbasin of site 5 and in the immediate subbasin of site 14 contribute heavily to the degradation of water quality at these two sites. Site 5 receives drainage from the central downtown business district of Charlotte, and drainage reaching site 14 comes from industrial land and the U.S. 29/74 interchange on Interstate 77.

On the whole, nonpoint sources appear to be the primary contributors of contaminants in the streams of Charlotte and Mecklenburg County. Runoff from downtown and industrial areas appears to contribute high concentrations of many trace elements. Runoff from residential and rural areas contributes high phosphorus concentrations. Effluent from some of the major waste-water treatment plants, particularly those on Irwin Creek and McMullen Creek, constitute the major point sources affecting the water quality in the County.

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